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REGULATORY CONTROL OF NUCLEAR SAFETY IN FINLAND

Annual report 2001

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Avainsanat: nuclear energy, nuclear facility, nuclear waste, regulatory control

Abstract

This report covers the regulatory control of nuclear safety in 2001. Its submission to the Ministry of Trade and Industry by the Radiation and Nuclear Safety Authority (STUK) is stipulated in section 121 of the Nuclear Energy Decree. The regulatory control of nuclear safety focused on the operation of Finnish nuclear facilities as well as on nuclear waste management and nuclear materials.

No event at nuclear power plants endangered the safe use of nuclear energy. No event at the FiR 1 research reactor was significant either. The doses of all nuclear power plant workers were below the individual dose limit. The collective occupational dose was low internationally. Radioactive releases were low and the dose calculated on their basis for the most exposed individual in the vicinity of Loviisa and Olkiluoto nuclear power plants was well below the limit established by the Government. In addition, the occupational radiation doses and radioactive releases into the environment from the research reactor were well below set limits.

The regulatory control of nuclear waste management focused on spent fuel storage and plans for final disposal as well as on the treatment, storage and final disposal of reactor waste. No events occurred in nuclear waste management that would have endangered safety. Nuclear material safeguards verified the use of nuclear materials in accordance with current regulations and the whereabouts of every batch of nuclear material.

The regulatory control verified that the operation of Finnish nuclear power plants, nuclear waste management and the use of nuclear materials complied with he current rules and regulations. In addition, STUK verified that nuclear liability in the event of nuclear damage has been taken care of according to legislation.

International co-operation continued, with financing from STUK's budget and external sources. Externally financed co-operation focused on the improvement of safety and radiation protection at Kola and Leningrad nuclear power plants as well as on the development of nuclear material control systems in Ukraine, the Baltic Countries and Russia.

The total costs of the regulation of nuclear safety in 2001 were FIM 42.7 million (7.2 M€). The total costs of operations subject to a charge were FIM 34.5 million (5.8 M€), the full amount of which was charged to the licensees and licence-applicants.

Contents

1 Preface

The Radiation and Nuclear Safety Authority (STUK) regulates the use of nuclear energy in Finland as prescribed in the Nuclear Energy Act (990/1987). STUK's responsibilities include control of physical protection, emergency planning and the use of nuclear energy to prevent nuclear proliferation. This is a report on the regulatory control in the field of nuclear energy, submitted by STUK to the Ministry of Trade and Industry once a year, as stipulated in section 121 of the Nuclear Energy Decree.

It covers the regulatory control of nuclear facilities, nuclear waste management and nuclear materials by the STUK Departments of Nuclear Waste and Materials Regulation (YMO) and Nuclear Reactor Regulation (YTO).

The report describes the regulatory control of nuclear facilities dealing with plant operation and operational events as well as safety improvements. The results of probabilistic safety analyses are given as well as worker radiation doses and collective doses, release data and the results of environmental radiation monitoring.

The nuclear waste management section discusses the final disposal of nuclear fuel and reactor waste treatment. It gives the end-of-year volumes of nuclear fuel and of reactor waste stored onsite.

Nuclear material safeguards at Finnish nuclear facilities are described as well as regulatory control of radioactive materials transport.

The report includes statistics on i.a. the distribution of working time between various tasks, the number of inspection days at the nuclear power plants and component manufacturers' premises as well as the number and processing time of reviewed documents.

In addition, the report includes preparation of regulations and some supportive functions, such as safety research, emergency preparedness, communication and development projects. Participation in international co-operation in the field of nuclear safety is described as well.

2 Regulatory control of nuclear safety —resources and development

2.1 Resources

The regulatory control of nuclear safety mostly focused on the Loviisa 1 and 2 nuclear power plant units owned by Fortum Power and Heat Oy and the Olkiluoto 1 and 2 units owned by Teollisuuden Voima Oy as well as on their nuclear waste management and nuclear materials. The planning and later implementation of the final disposal of nuclear fuel, which is part of nuclear waste management, is taken care of by Posiva Oy. Subject to the regulatory control were also the research reactor operated by the Technical Research Centre of Finland, small-scale users of nuclear materials as well as transportation of radioactive materials. This chapter gives an overall account of the control exercised by STUK and includes statistics on the regulatory control. The activities subject to the regulatory control are described in more detail in Chapters 4, 5 and 6 as well as in Appendices 6 and 7.

The duty area of nuclear safety regulation included basic operations subject and not subject to a charge. Basic operations subject to a charge were comprised of the regulatory control of nuclear facilities, with their costs charged to the licensees. Those basic operations not subject to a charge included international and domestic co-operation as well as emergency response and communications. The basic operations not subject to a charge are publicly funded. The overheads due rule-making and support functions (administration, development projects, training, maintenance and development of expertise as well as reporting) were carried forward into the costs of the both types of the basic operations and of contracted services, in relation to the number of working hours worked for spent on each function.

Distribution of working hours at each duty area is given in Table I.

The time spent on the regulatory control of Loviisa nuclear power plant was 11.8 man-years, which is 14.3 % of the total working time of the personnel. The time spent on the regulatory control of Olkiluoto nuclear power plant was 13.1 man-years, i.e. 13.5% of total working time. Besides the regulatory control of the nuclear power plants these figures include the regulatory control of nuclear materials. The time spent on the regulatory control of the nuclear waste management was 3.0 man-years, i.e.3.7% of total working time. The regulatory control of the FiR 1 research reactor took 0.1 man-years and the preparation of a preliminary safety evaluation for a fifth reactor in planning 0.2 man-years. The regulatory contro of the small-scale users of nuclear materials took 0.02 man-years. Fig 1 gives the distribution of working time spent on the main functions.

The number of inspection days onsite and at the component manufacturers' premises totalled 635. In addition to inspections focused on the safety of the nuclear power plants, the figure includes inspections of nuclear waste management and nuclear materials. Two resident inspectors worked at Olkiluoto nuclear power plant and one at Loviisa plant. The number of inspection days over the past years is given in Fig 2.

The total number of documents submitted to STUK for review in 2001 was 1414. The number of documents submitted in 2001 and earlier, whose review was completed, was 1303. The figure includes the licences granted by STUK in accordance with the Nuclear Energy Act, which are given in Appendix 2, and the decisions on nuclear power plant personnel given in Appendix 3. Average document review time was 58 days. The yearly number of documents and their average review times are given in Fig 3. Figs 4 and 5 give the distribution of review times of documents on Loviisa and Olkiluoto plants. Reports for 21 events at

Table I. Distribution of working hours at each duty area.

Duty area	man-year				
	1997	1998	1999	2000	2001
Basic operations subject to a charge	29.1	24.7	25.3	26.4	26.3
Basic operations not subject to a charge	4.4	4.6	5.5	7.5	7.4
Contracted services	8.2	6.9	7.0	5.4	4.4
Rule-making and support functions	23.8	25.1	24.6	25.5	28.5
Holidays and days of absence	14.7	13.9	14.8	15.0	16.0
Total	80.2	75.2	77.2	79.8	82.6

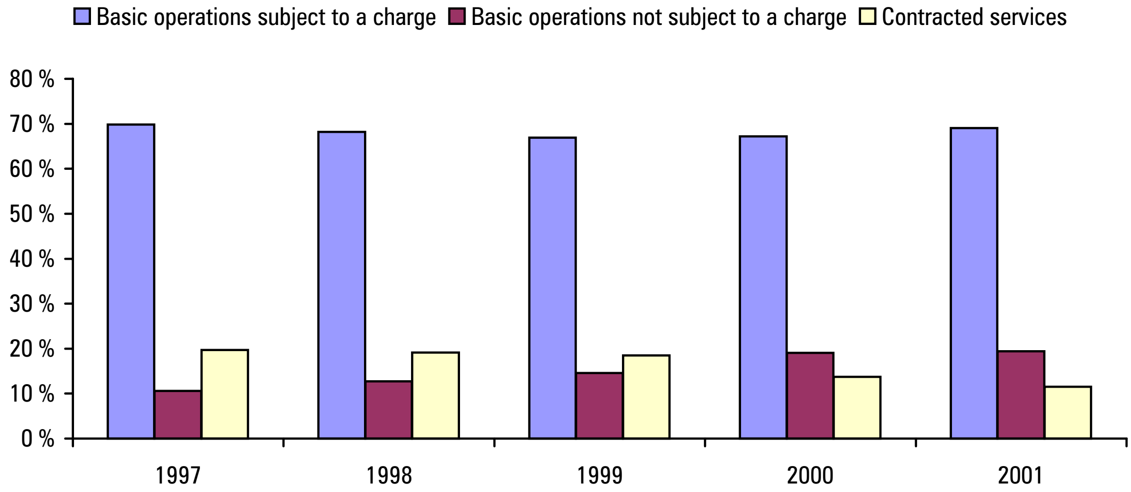

Figure 1. Working time spent on main functions.

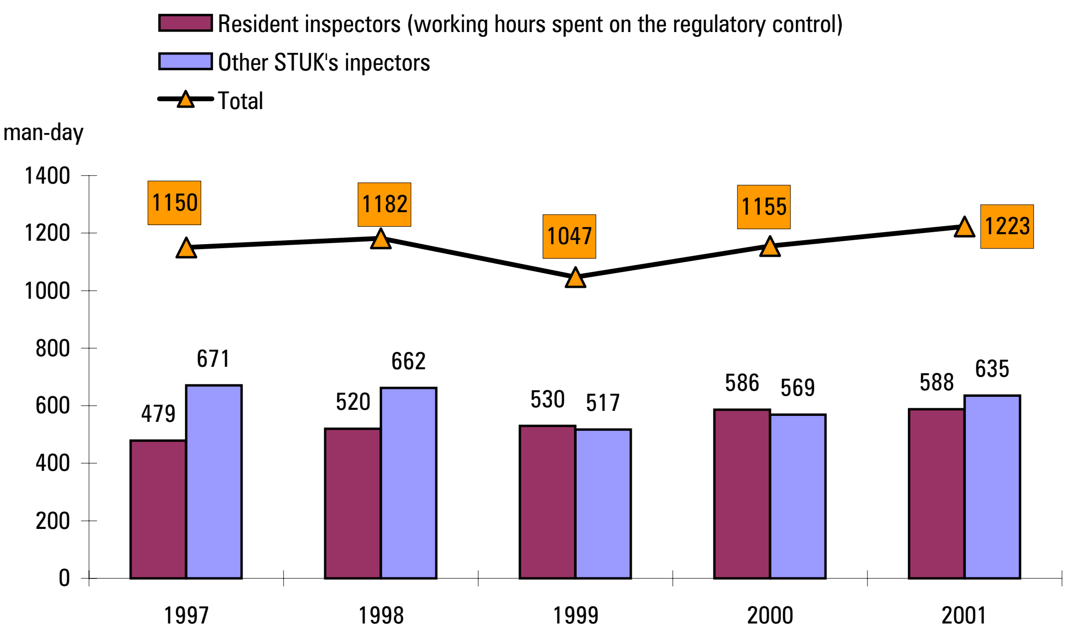

Figure 2. Number of inspection days onsite and at component manufacturers' premises.

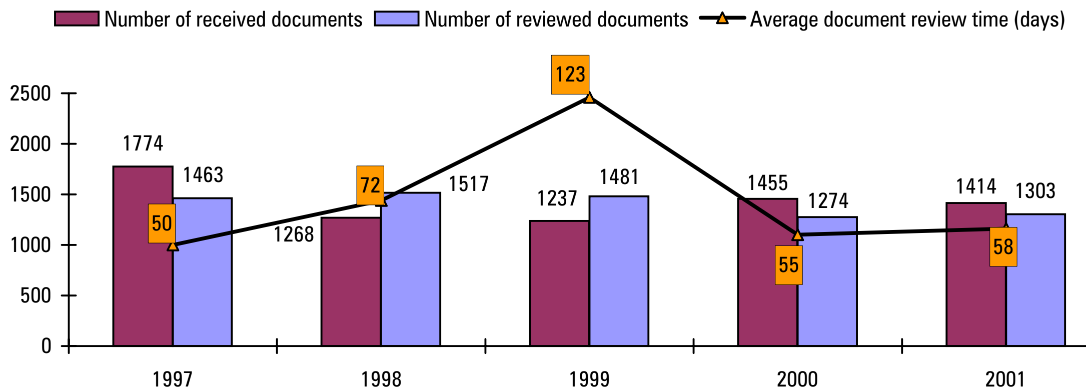

Figure 3. *Number of documents received and reviewed as well as the average document review time.*

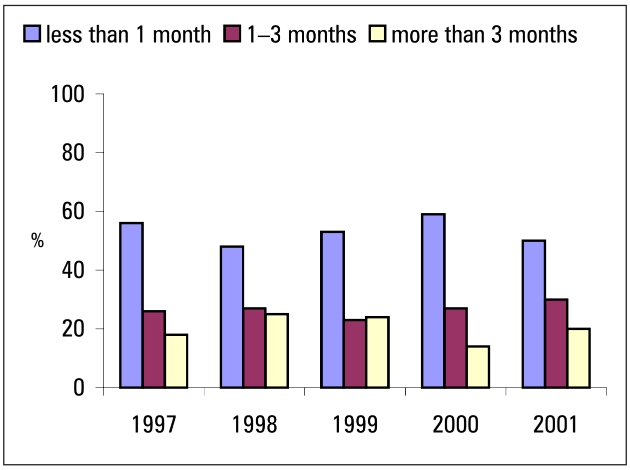

Figure 4. *Distribution of time spent on preparing decisions about the Loviisa plant units.*

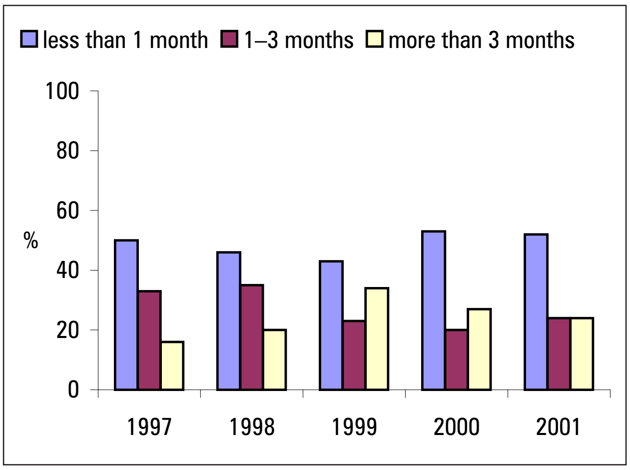

Figure 5. *Distribution of time spent on preparing decisions about the Olkiluoto plant units.*

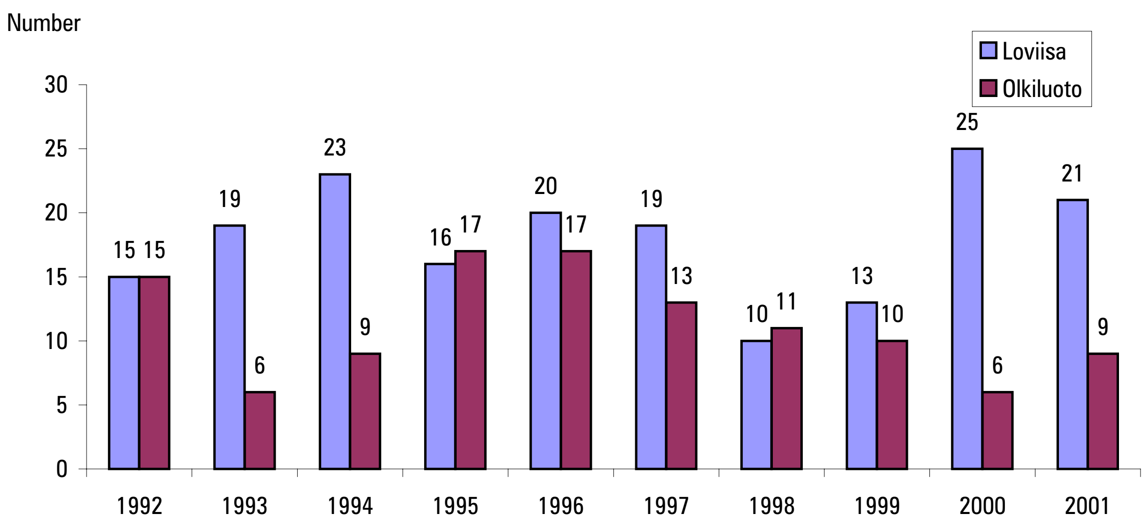

Figure 6. *Number of event reports submitted by Loviisa and Olkiluoto nuclear power plants.*

Loviisa nuclear power plant and for nine events at Olkiluoto nuclear power plant were submitted to STUK. The number of event reports over the past years is given in Fig 6. The licensees regularly submitted to STUK daily reports, quarterly reports, annual reports, outage reports, annual environmental radiation safety reports, monthly individual radiation dose reports, annual operational experience feedback reports and safeguards reports.

STUK concluded that the Finnish nuclear power plants were operated according to valid regulations.

2.2 Development projects

Development of information management

The development of information management relating to nuclear safety regulation was continued. The focus was on Microsoft's Share Point Portal Server (SPS), which was assessed as an applicable information tool. It's benefits included complete integrability with the office applications used in STUK (the Microsoft Office Family) and its relatively easy manageability using own expertise. When choosing software for testing SPS's economic price and the fact that it would most likely meet STUK's data management requirements were noted as well.

SPS testing was discontinued after installation to test the applicability of a corresponding product in the SAP product family. Since STUK's financial administration already uses SAP software products this was to find out whether a SAP family product would help meet the same objectives as SPS, ensuring at the same time integrity with the software used by financial administration. The comparison made showed that the objectives of information management in nuclear safety regulation can be attained even using SAP software products.

Based on the comparison made, it was decided to complete the testing of the SPS software in early 2002 and to participate thereafter in a SAP software testing at STUK.

In addition to the above software comparisons and tests, discussions with Fortum Power and Heat Oy and Teollisuuden Voima Oy, operators of the Finnish nuclear power plants, were continued to establish shared Extranet solutions. In addition, the development of information management tools (identification procedures, electronic identification card) and associated procedures (electronic services) in public administration were followed.

Organisational safety culture

In the field of safety culture the focus was in the development of regulatory work. To evaluate safety culture, collection of observations from STUK's inspectors was commenced. A list of the manifestations of safety culture had been collected to guide observation, and training was arranged for inspectors. Further work on the observations will be within the periodic inspection programme. This procedure was tested in 2001. The results were considered beneficial and further development is going on.

STUK's aim is to extensively develop safety culture within the whole of the Finnish nuclear sector. A strong safety culture means

- awareness of the specific features and procedures of own organisation as well as their relation to safety objectives
- target-oriented development of own organisation and its operation as well as interaction between different organisations to assure safety, and
- willingness to observe safety-related factors in management, organisation unit/group relations, procedures and atmosphere, and to react to them.

In connection with safety culture evaluation planning was started to facilitate the handling of organisational change. By means of research STUK has striven to provide prerequisites for the development of safety culture. Research related to safety culture assessment has been done since 1999 and the work continues.

Development of own operation

The development of STUK's own work focused on the completion of old projects. The project to develop organisational culture, started in 1999, yielded a wealth of ideas for whose implementation persons were chosen and time schedules set up.

A Balanced Score Card (BSC) project was launched and strategic success factors were defined. To improve the BSC indicators STUK has participated in national and international co-operation for measurement of the effectiveness of regulatory activities.

In 2001 the EFQM criteria (European Foundation for Quality Management Excellence Model) were introduced as a self-assessment tool. On the basis of an evaluation, a decision was made in 2002 to carry out competence analyses in preparation of a personnel plan and to continue improvement of working culture. Maintenance and development of the quality management system continued in 2001 based on earlier lines of policy.

As a development project derived from the strategy of nuclear safety control, the modified organisation of the department of Nuclear Reactor Regulation was prepared in autumn 2001 and implemented at the beginning of 2002.

2.3 Finances

In 2001, the costs of the regulatory control of nuclear safety subject to a charge were FIM 34.5 million (5.8 M€). The total costs of nuclear safety regulation were FIM 42.7 million (7.2 M€). Thus the share of activities subject to a charge was 81%.

The 2001 income from the regylatory control of nuclear safety was FIM 34.5 million (5.8 M€). Of this, FIM 14.5 million (2.4 M€) and FIM 14.9 million (2.5 M€) came from the regulatory control of Loviisa and Olkiluoto nuclear power plants, respectively. The regulatory control of Posiva Oy's operations yielded FIM 4.7 million (0.8 M€). The income from other objects of the regulatory control (i.a. regulatory control of the FiR 1 research reactor, preparation of a preliminary safety evaluation for the fifth reactor in planning, regulatory control of small-scale users of nuclear materials) was FIM 0.4 million (0.07 M€). Figure 7 gives the annual income and costs of the regulatory control of nuclear safety over the recent years.

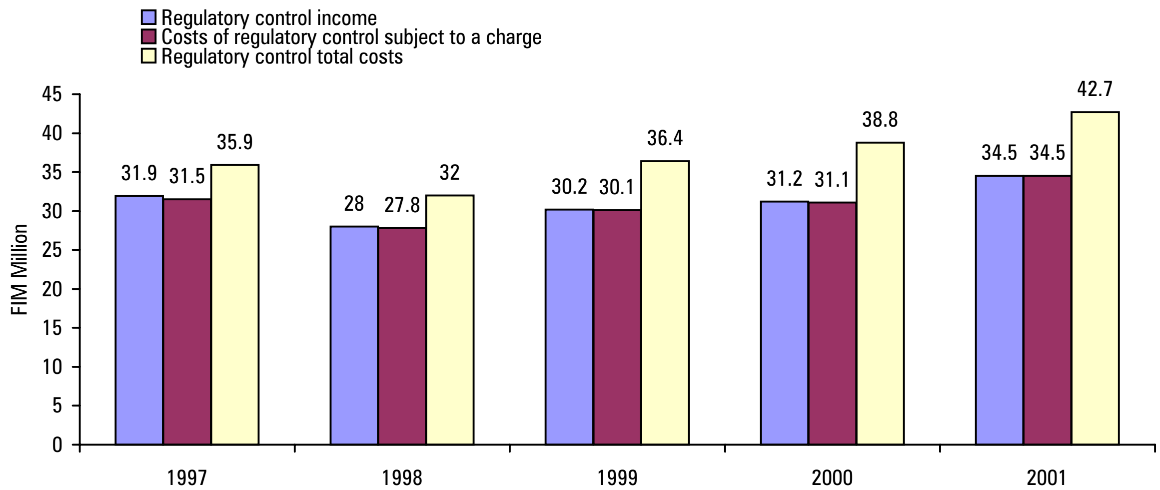

Figure 7. *Regulatory control of nuclear safety income and costs.*

3 Regulatory guides

The need to update the Government Resolutions (395), (396) and (397) on general regulations for the safety of nuclear power plants, and on the plants' physical protection and emergency preparedness was assessed. The resolutions originate in 1991. The assessment showed a need for updating. Since only minor checks in content would be required, not large basic alterations, updating is not considered urgent.

No significant amendments to the Nuclear Energy Act or Decree were prepared by STUK and no such amendments entered into force in Finland in 2001.

STUK publishes YVL guides that are detailed safety regulations for nuclear facilities. The guides describe STUK's regulatory procedures as well. STUK decides, case by case, how new guides apply to facilities already in operation and what is the guides' degree of obligation in each case. The issuing of YVL guides is based on the Nuclear Energy Act (990/1987) and the Government Resolution (395/1991) on the general safety regulations for nuclear power plants. The revision and updating of the YVL guides was continued. About 50 guides were prepared or assessed in 2001. By the end of the year, three guides were completed and four were in the process of being approved. In addition, drafts of several guides were well into completion.

The number of guides published in Finnish is given in Fig 8. Two were published in English. Translation into Swedish was started.

YVL guides and other essential nuclear safety regulations have been available through STUK's network for a few years already. In 2001 this software application, "Ydintieto" (Nucinfo), was converted to a format accessible by a web browser and was integrated with STUK's Intranet.

STUK prepared to the IAEA national statements on 12 draft safety guides that are listed in Appendix 3.

A self-assessment of the Finnish nuclear safety regulations, launched in 2000, was complemented with an external study commissioned to the Technical Research Centre of Finland (VTT), focusing on the domestic guides' degree of prescriptive guidance and their coverage. The study mapped the opinions and experiences of licensee representatives to sketch a picture of the prescriptive nature of the Finnish regulations potentially considered harmful. The study concluded that the guides' degree of detail is not harmful. In addition, objects of development were identified, e.g. assurance of the consistent interpretation of regulations. On the basis of these two assessments, STUK's new regulatory guide strategy was sketched in 2001. In addition, the results were submitted to the international community in the form of a second report under the Nuclear Safety Convention.

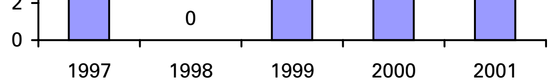

***Figure 8**. Number of published YVL guides.*

4 Regulatory control of nuclear facilites

4.1 Regulatory control of nuclear safety

The regulatory control of nuclear safety of the nuclear power plants included periodic inspections and inspections the licensee was obliged to separately request during measures carried out at the facility, or that were conducted by STUK at its discretion. In addition, the safety of nuclear power plants was assessed by STUK on the basis of i.a. operating experience, safety analyses as well as reports and plans submitted by the licensee, and by inspections onsite and at component manufacturers' premises.

Inspections in the periodic inspection programme are listed in Appendix 1. Inspections in accordance with the programme are, as a rule, repeated every year; however, the contents of individual inspections may change year by year. The annually inspection programme is brought to the knowledge of the licensee at the beginning of every year and inspection days are agreed upon with the licensee. In 2001 there were 16 inspections at Loviisa plant and 15 at Olkiluoto plant. The plant's management and procedures, the function of its organisational units and the technical acceptability of its systems were looked into. The inspections comprised personnel interviews and walk rounds to verify facts and oversee tests, among others. As part of the programme, one unannounced inspection was conducted at Loviisa plant. Focus was on work permit procedures prior to and during an annual maintenance outage.

A total of 87 remarks were issued in the 2001 inspections. Of those given to Loviisa plant, the most significant for safety were about shortcomings in the management of plant modifications, in the procurement and quality control of electrical and I & C equipment and in the monitoring of steam generator loads. Correspondingly, the most significant remarks to Olkiluoto plant were about shortcomings in the management of plant modifications and the monitoring and evaluation of the periodic inspection programme. Additionally at Olkiluoto plant, specific attention was paid to the utilisation of failure statistics in the assessment and improvement of plant safety. Loviisa and Olkiluoto plants will act upon the remarks, and they already have, to correct the situation. None of STUK's observations would have essentially affected plant safety.

STUK controlled the implementation of component and structural modifications by inspections onsite and at component manufacturers' premises and by means of licensee reports. Modifications to improve plant safety are described in subsections 4.2.4 and 4.3.4 as well as in Appendix 7. The regulatory control of modifications comprised of the identification of their need, the definition of the scope of required regulatory attention, the reviewing of relevant documents as well as the monitoring of implementation and commissioning. In consequence of the modifications several documents on plant operation and layout, such as the Technical Specifications, the Final Safety Analysis Report and procedures were revised. The revisions were reviewed by STUK. One part of the regulatory control were meetings arranged between STUK and the licensee. In the meetings licensee's representatives clarified planned modifications and the status of ongoing modification projects. STUK has set up an independent data base for plant modifications monitoring.

During annual maintenance outages regulatory control focused on, among others, the administration of work during the outages, the activities of the operating and maintenance personnel, refuelling, inspections and tests by the licensee and subcontractors as well as radiation protection. STUK supervised the shutdown of the plant units and their startup after the outages. The outages are described in more detail in Appendix 5.

One form of the regulatory control was event investigation. STUK appoints a team to investigate a plant event especially when the licensee's organisation has not operated as planned or when an event is assessed to lead to significant modifications in the plant or its procedures. In addition, a STUK investigation team is set up if the licensee has not investigated an event's root causes well enough.

The licensees assess their plant events, taking action, if necessary. STUK assesses these licensee measures as part of the regulatory control. STUK assesses also its own activities in connection with the events. STUK did not initiate any new event investigations in 2001. Two in 2000 initiated investigations were completed. These investigations were "Non-compliances with the Technical Specifications and human-based common cause failures" and "Delays and deficiencies in implementing of a risk reducing modification at Loviisa nuclear power plant". Measures taken in 2001 on account of the investigations are described in subsections 4.2.3 and 4.3.3.

The Nuclear Energy Act prescribes that STUK is responsible for verifying that a operator's liability in case of nuclear damage complies with statutory requirements. The Insurance Supervision Authority reviews the contents of liability arrangements. The control procedure is explained in detail in Guide YVL 1.16 "Control of nuclear liability insurance policies". Licensees have submitted the necessary documents to STUK according to a procedure set forth in the guide. STUK verified that the arrangements comply with the relevant stipulations.

4.2 Loviisa nuclear power plant

4.2.1 Operation and operational events

Both units of Loviisa nuclear power plant operated reliably. The load factor of Loviisa 1 was 92.1% and that of Loviisa 2 was 89.0%. The duration of the annual maintenance outages was 20 days at Loviisa 1 and 22 days at Loviisa 2. The course of the outages and the actions taken are described in Appendix 5.

One reactor scram occurred at Loviisa 1. The cutting of a live cable caused a short circuit in consequence of which containment isolation valves, among others, closed. The operator noticed this and manually tripped the reactor. The event is described in more detail in Appendix 6. There was also a brief production break at Loviisa 1 to check the steam generator space after a lubricating oil leak from a primary coolant pump motor. Besides the annual maintenance outage there were no other production breaks at Loviisa 1. In addition to the annual maintenance outage, Loviisa 2 was briefly brought to shutdown state for control rod drive shroud repairs. Production losses due to component malfunctions were 0.7% at Loviisa 1 and 0.7% at Loviisa 2.

Figure 9 gives the daily average gross powers of the plant units in 2001. Load factors and the number of reactor scrams over the past years are given in Figures 10 and 11.

No safety-significant events occurred at the Loviisa plant units. The most significant events, none of which were above INES Level 0, are described in Appendix 6. The total number of INES Level 1 and above events at Finnish nuclear power plants over the past years is given in Fig 12.

4.2.2 Non-compliances with the Technical Specifications

At the Loviisa plant units the following three events were in non-compliance with the Technical Specifications:

- Ventilation system of Loviisa 1 diesel generator room partially inoperable
- Control rods were inserted deeper into the Loviisa 1 reactor core than allowed by the Technical Specifications
- A position switch of a containment underpressure valve was inoperable at Loviisa 1.

Detailed descriptions are given in Appendix 6.

The licensee has planned, and already partly implemented, measures to prevent recurrence. The number of non-compliance with the Technical Specifications over the past years is given in

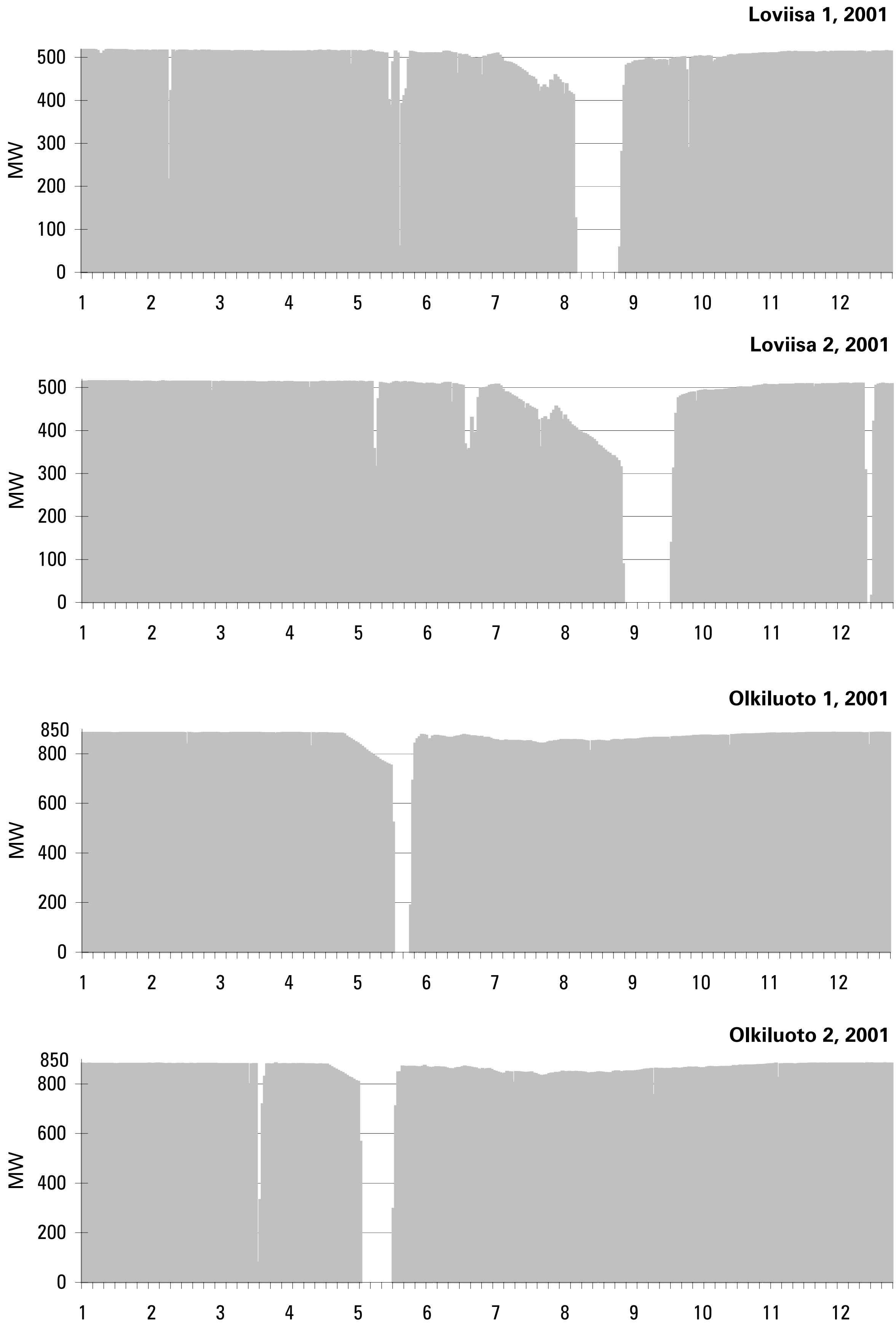

Figure 9. *Daily average gross power of the Loviisa and Olkiluoto plant units in 2001.*

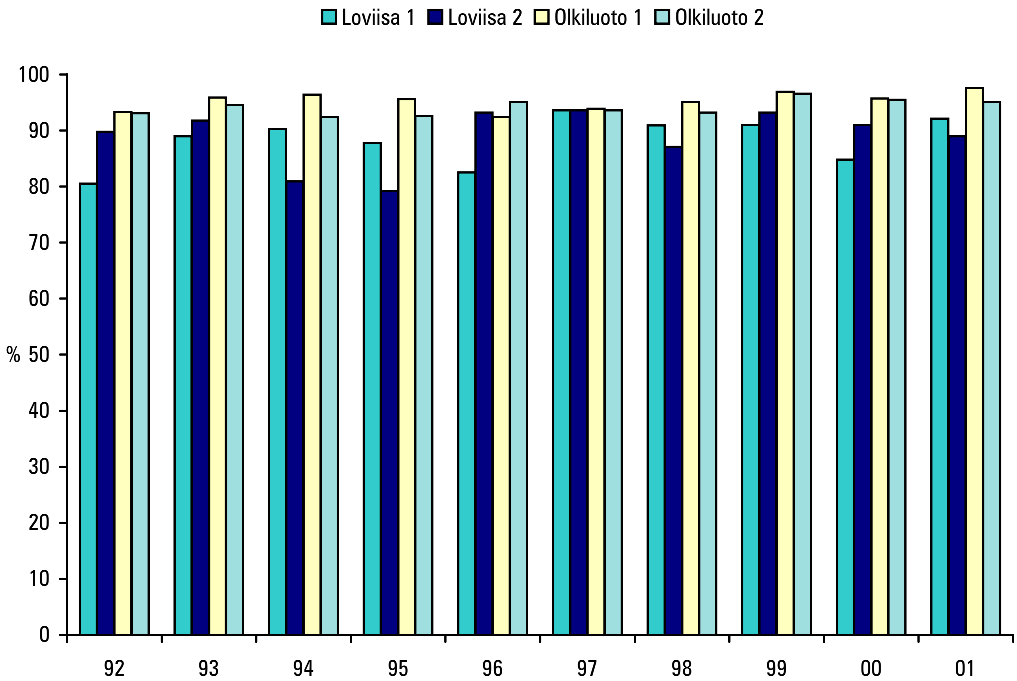

Figure 10*. Load factors of the Loviisa and Olkiluoto plant units.*

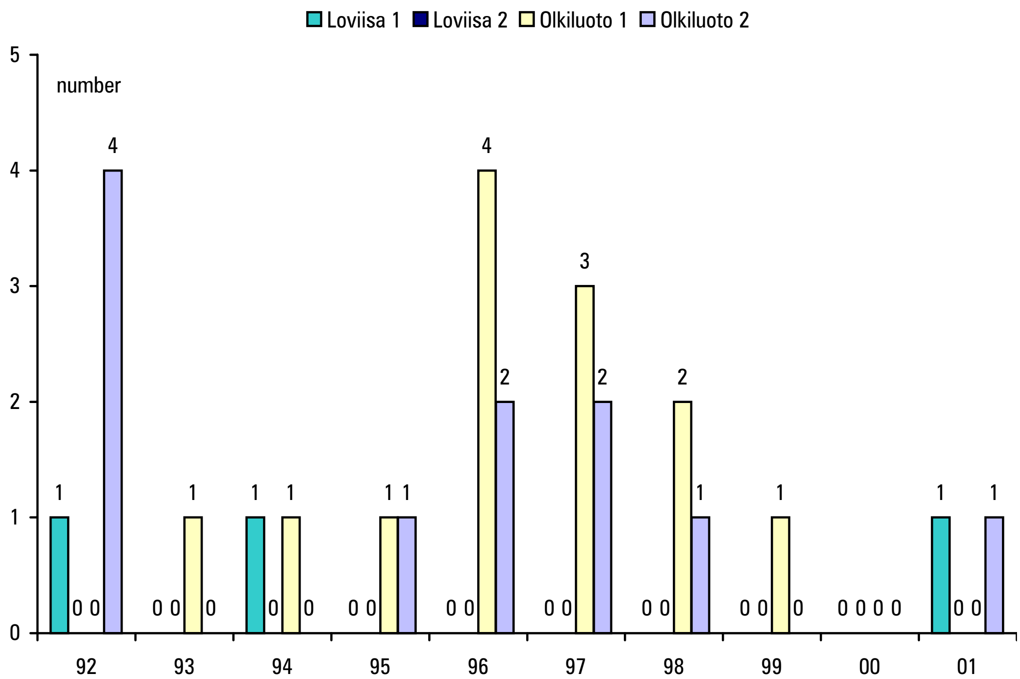

Figure 11. *Number of reacator scrams at the Loviisa and Olkiluoto units, scram test excluded (reactor power exceeds 5%).*

Fig 13. Olkiluoto events are discussed in subsection 4.3.2.

The licensee also applied in advance for STUK's approval to exempt from the Technical Specifications. In 2001 STUK granted three such exemptions for the Loviisa plant units. The yearly number of exemptions is given in Fig. 14.

4.2.3 Event investigation

Non-compliances with the Technical Specifications

Investigation of non-compliances with the Technical Specifications looked into underlying common factors as well as into the possible causes of their increase. It was conducted in 2000 and concerned both Loviisa and Olkiluoto facilities. Annual Report 2000 (STUK-B-YTO 208) discusses the investigation and Annual Report 1999 (STUK-B-YTO 202) events which lead to the investigation.

Based on the investigation, STUK recommended that the licensees re-evaluate their procedures for recognising changed situations and for taking into account change impact in sufficient scope in re-planning and re-schedulling. They should also find out how to reduce excessive routine in their work. Alertness of action should be fostered, especially when pressed for time and during abnormal situations. These matters should be emphasised in training as well. In their event investigations, the licensees should more pay attention than before to the observation and elimination of human error and should include their observations in event reports as well.

Loviisa power plant made an action plan on account of the above recommendations. STUK follows the status and implementation of the projects, improvements and development needs as part of the periodic inspection programme. The number of events in non-compliance with the Teachnical Specifications has decreased at Loviisa plant.

Measures concerning Olkiluoto facility are described in subsection 4.3.3.

Delays and deficiencies in implementing of a risk reducing modification at Loviisa nuclear power plant

The delay of a modification assuring sealing water supply to the primary coolant pumps of Loviisa nuclear power plant was looked into. Pump shaft sealing and sealing water cooling require water. The modification's implementation at Loviisa 2 was due in the 2000 annual maintenance outage. Loviisa plant had decided the matter in July 1999. The modification was not made, however, because related utility design documentation was insufficient and belated. Handling at STUK was behind

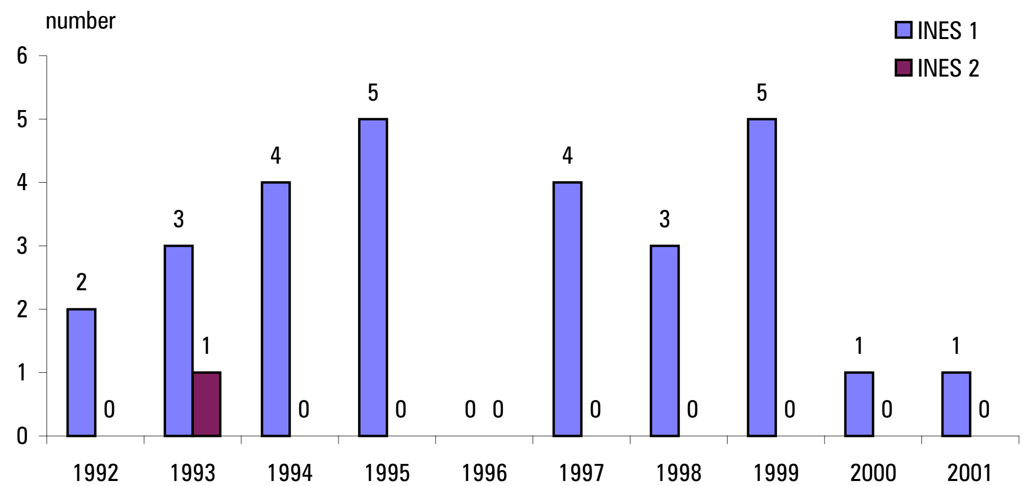

__Figure 12.__ Events at INES Level 1 and above at the four Finnish plant units.

schedule as well and an approval could not be completed in time for the work to be done during the planned annual maintenance outage. Investigation into the matter is explained in Annual Report 2000 (STUK-B-YTO 208).

Deficiencies in the pre-inspection documentation submitted to STUK included lacking component-level pre-inspection documents of safety-important sensors and ambiguous I & C equipment design criteria. The licensee's decision to submit insufficient documentation was partly due to the postponement of the commencement of I & C equipment and component design close to planned installation date. In addition, the submitted documents did not present or justify the deviations made from the YVL guides, which hampered STUK's review of the documents.

Handling of the document by STUK was delayed mostly because of insufficient inter-unit communication due to which the modification's importance was not recognised widely enough. In its early stages the modification had been discussed at departmental meetings but this did not prevent the delay. At the time of the event's progress, STUK did not yet concentratedly manage modification entities.

The modification was implemented at both Loviisa plant units in the 2001 annual maintenance outages (see 4.2.4 and Appendix 7). The development needs observed in STUK's operation have been taken into account in instructions (i.a. document handling and modification management) of STUK's Quality Manual.

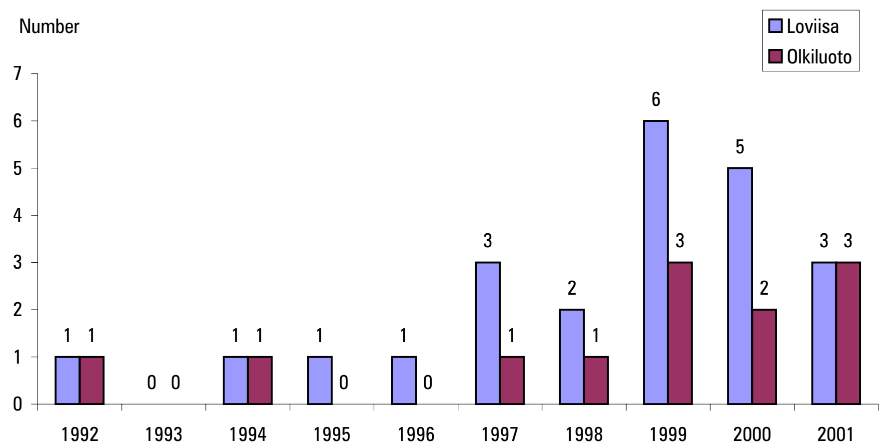

Figure 13. *Number of plant events in non-compliance with the Technical Specifications at Loviisa and Olkiluoto nuclear power plants.*

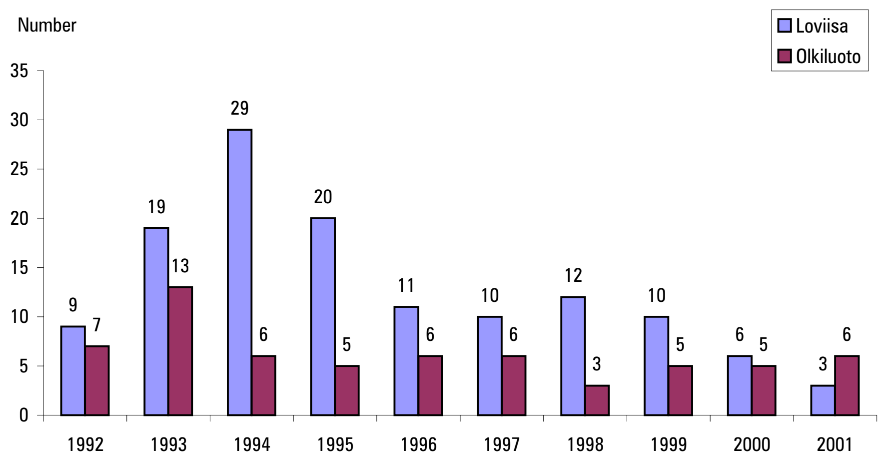

Figure 14. *Number of exemptions from the Technical Specifications at Loviisa and Olkiluoto nuclear power plants.*

4.2.4 Safety improvements

Safety improvements were continued at both plant units. They were based on new safety requirements in YVL guides set forth after the plants' commissioning, on results of the probabilistic safety analysis and, partly, on operational experiences.

Loviisa 1 and, to some extent, Loviisa 2, continued improvements for severe accident management planning. Modifications focused on the assurance of reactor pressure vessel external cooling in a core melt situation following a severe accident. At Loviisa 2 the reactor pit was prepared for external core cooling. In addition, systems for the management of hydrogen generated during accidents were improved. Hydrogen flow from reactor building lower plenum, to ice condensers, to upper plenum was assured by the installation of devices opening the lower doors of the ice condensers during a severe accident. A control room for severe accident management was commissioned at Loviisa 1.

The operational parameters of pressurised emergency water tanks were changed in connection with emergency cooling system modifications to improve the plant units' accident behaviour. Owing to this, fuel cladding temperatures in worst-case accidents (a primary circuit large leak) will be essentially lower than before. The raising of fuel maximum burnup by 12.5% could be consequently accepted. Because of this change the fuel can be used in the reactor longer than before, reducing the volume of high-level active waste.

On the basis of the results of probabilistic analyses improvements were required in the primary pump coolant sealing water system. The modification was implemented at both plant units such that the cooling of primary coolant pump sealings was assured by a change-over taking place on the basis of sealing water temperature, using pumps of the primary make-up system circuit. This assures the system operation in transients and accidents.

To reduce the risk of containment external leaks, an isolation valve was installed in the reactor building drainage system and the connection between the reactor building venting system and outlet line was removed.

In addition, some modifications based on operational experiences were made at the plant units. These included a renewal of the fire detection system and hydrogen units at both plant units as well as of service water system pump motors at Loviisa 2. Recoating of the steam generator room floor was started at Loviisa 1.

Safety improvements are described in Appendix 7.

4.2.5 Probabilistic safety analyses

The licensee complemented probabilistic safety analysis by a study assessing the risk from leaks from the primary circuit bypassing the containment via various systems (VLOCA). Leaks postulated in the analysis exceed 5kg/s. According to the analysis, leaks from the heat exchangers of the primary coolant sealing water system and pipe breaks external to the containment would lead to a temperature increase in the reactor building lower plenum. Such an increase could result in the malfunctioning of measuring transmitters. The analysis results led to modifications at the plant units to reduce the risk of VLOCA. Implemented modifications are described in Appendix 7. Further modifications are in the planning for implementation at a later date.

Another assessment by the licensee concerned the risk arising from very small leaks from the primary circuit bypassing the containment (XSLOCA). The leak volume would be less than 5kg/s. Due to their small volume, the emergency core cooling system is not needed to compensate for the leaks as is the case with larger leaks. STUK's review focused in assessing analysis conclusions and risk reduction measures. At STUK's request the licensee submitted a report on the risk-reducing measures planned.

The combined VLOCA/XSLOCA core melt risk frequency, as assessed by the licensee, is ca. 10^{-4}/year. Several VLOCA/XSLOCA related plant modifications are due in the 2002 annual maintenance outage. After their completion, VLOCA/XSLOCA induced core melt frequency is assessed to be reduced to ca. a tenth part of the original. Level 1 PSA core melt frequency, all intiating events included, would then be ca. 10^{-4}/year. Maximum Level 2 PSA release frequency would be $6 \cdot 10^{-6}$/year (internal initiating events only). Level 1 PSA assesses reactor core melt probability and Level 2 PSA the volume, probability and timing of radioactive releases from the containment.

4.2.6 Radiation safety

The radiation doses of those who worked at Loviisa nuclear power plant in 2001 were below the 50 mSv annual limit. The distribution of individual doses in 2001 is given in Table II. The highest individual dose at Loviisa nuclar power plant was 12.4 mSv. It accumulated during the annual maintenance outages.

In addition, individual radiation doses did not exceed the dose limit of 100 mSv over any period of five years. The highest individual dose to a Finnish nuclear power plant worker in the 5-year period 1997–2001, 85.1 mSv, was received at Loviisa nuclear power plant.

The collective occupational radiation dose for both Loviisa plant units in 2001 was 1.13 manSv. The collective occupational dose was 0.76 manSv at Loviisa 1 and 0.37 manSv at Loviisa 2. The collective occupational doses incurred over the past years at Loviisa and Olkiluoto power plant are given in Fig. 15. The yearly collective dose is mostly incurred in outage work.

Occupational radiation doses incurred in the annual maintenance outages are given in Appendix 5. According to guidelines set by STUK, the threshold guideline for the collective dose for one Loviisa plant unit is 2.5 manSv per one gigawatt of net electric power averaged over two successive years. This means 1.22 manSv per one Loviisa plant unit. At Loviisa 1 this 2-year average design value was exceeded by 0.04 manSv, which was due to a greater-than-usual amount of planned and unplanned work as well as of a prolonged 2000 annual maintenance.

Radioactive releases into the environment from Loviisa nuclear power plant in 2001 were well below authorised limits. The releases of gaseous radioactive effluents were 0.03% of authorised limits. In the releases of radioactive noble gases, the activation product of argon-40, i.e. argon-41, originating in the air space between the reactor pressure vessel and the biological shield, was dominant. The releases of radioactive iodine were below the detection limit. The tritium content of liquid effluents, 14 TBq, is ca. 10% of the release limit. The total activity of other liquid effluents was 1.3 GBq, i.e. ca. 0.2% of the release limit. Detailed information about the releases is given in Table III.

Table II. *Occupational radiation dose distribution at Loviisa and Olkiluoto plant units in 2001 for different work categories.*

Dose range (mSv)	Number of persons by dose range Loviisa	Olkiluoto	total*
< 0,5	224	349	514
0.5–1	105	225	299
1–2	119	199	315
2–3	65	104	167
3–4	43	36	94
4–5	24	16	52
5–6	14	10	36
6–7	13	9	23
7–8	10	5	17
8–9	7	1	9
9–10	2	1	3
10–11	6	1	12
11–12	1	2	2
12–13	2	1	6
13–14	–	–	1
14–15	–	–	1
15–16	–	–	–
16–17	–	–	–
17–18	–	–	–
18–19	–	–	–
19–20	–	–	–
20–25	–	–	–
> 25	–	–	–

* The data in these columns also include Finnish workers who have received doses at Swedish nuclear power plants. The same person may have worked at both Finnish nuclear power plants and in Sweden.

The function of the release limits is to keep annual individual exposure in the vicinity of nuclear power plants, arising from the operation of the plants, well below the 100 µSv threshold value given in the Government Resolution (395/1991). The dose to the most exposed individual in the environment of the nuclear power plants, calculated on the basis of releases, was ca. 0.35 µSv, i.e., 0.4% of the set limit. Calculated annual radiation doses are given in Fig. 16.

Radiation monitoring in the environment of nuclear power plants comprises onsite and offsite radiation measurements as well as determination of radioactive substances to establish the population radiation exposure and radioactive substances present in the environment.

In the vicinity of Loviisa nuclear power plant, 294 samples were analysed in accordance with a monitoring programme. Radioactive substances originating in Loviisa plant were measurable in three samples of air, four samples of deposition, one samle of bottom fauna, 10 samples of aquatic plants, nine samples of sinking matter and four samples of sea water. Cobalt-60 was a dominating plant-based radioactive substance measured in all of the aforementioned samples. The total number of observations was 19. The next most common radioactive substances were the radioactive iso-

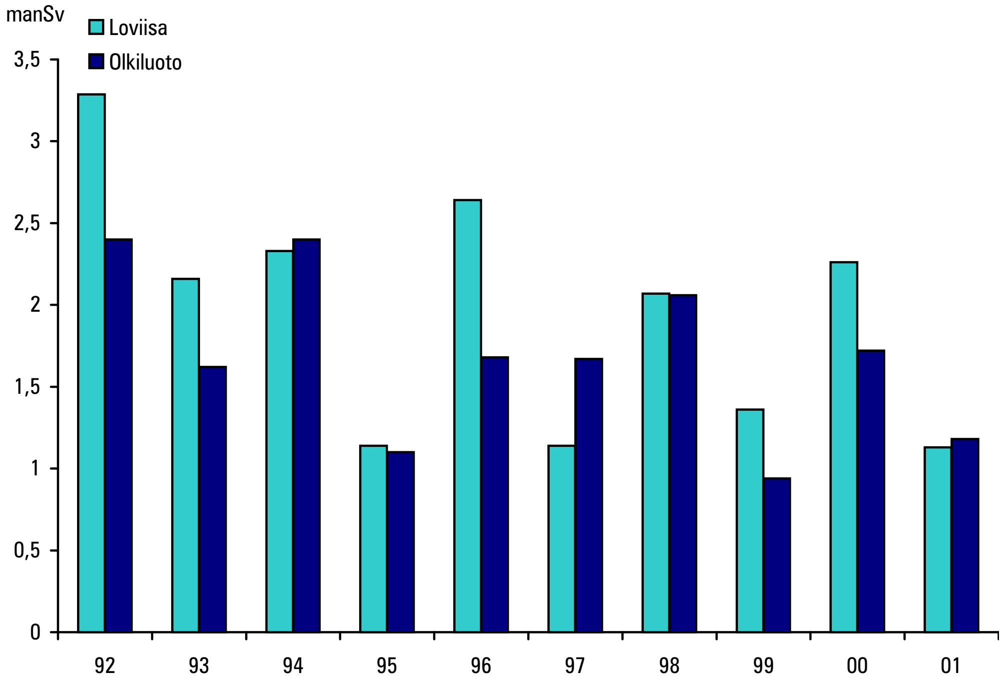

Figure 15. *Collective occupational doses at Loviisa and Olkiluoto nuclear power plants.*

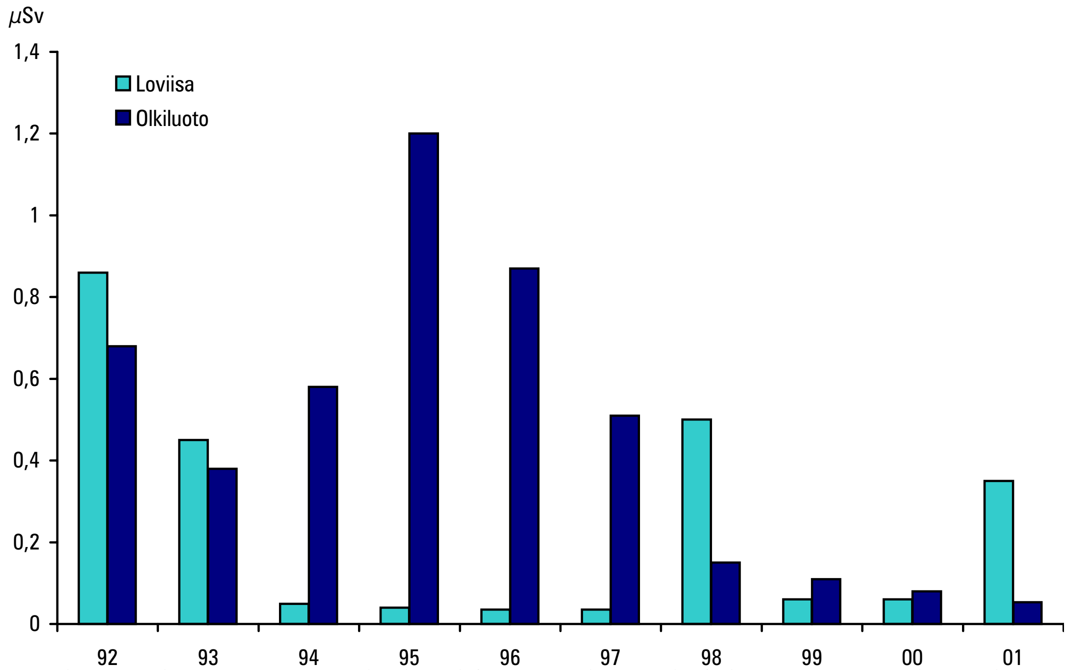

Figure 16*. Radiation dose estimates calculated for an indivisual of the most exposed population group in the vicinity of Loviisa and Olkiluoto nuclear power plants.*

Table III. Measured radioactive releases from Loviisa and Olkiluoto plants in 2001.

Gaseous effluents by nuclide group (Bq) a)

Plant site	Noble gases (Krypton-87 equivalents	Iodines (Iodine-131 equivalents lentteina)	Aerosols	Tritium	Carbon-14
Loviisa					
Release in 2001	$5.0 \cdot 10^{12}$	– b)	$4.1 \cdot 10^{7}$	$1.9 \cdot 10^{11}$	$3.1 \cdot 10^{11}$
Annual release limit	$2.2 \cdot 10^{16}$ c)	$2.2 \cdot 10^{11}$ c)			
Portion of the release limit	0.03%				
Olkiluoto					
Release in 2001	$5.7 \cdot 10^{10}$	– b)	$3.3 \cdot 10^{7}$	$3.9 \cdot 10^{11}$	$8.7 \cdot 10^{11}$
Annual release limit	$1.77 \cdot 10^{16}$	$1.14 \cdot 10^{11}$			
Portion of the release limit	0.0004%				

Liquid effluents by nuclide group (Bq) a)

Laitospaikka	Tritium	Other nuclides
Loviisa		
Release in 2001	$1.4 \cdot 10^{13}$	$1.3 \cdot 10^{9}$
Annual release limit	$1.5 \cdot 10^{14}$	$8.9 \cdot 10^{11}$ c)
Portion of the release limit	10%	0.2%
Olkiluoto		
Release in 2001	$9.0 \cdot 10^{11}$	$8.7 \cdot 10^{8}$
Annual release limit	$1.83 \cdot 10^{13}$	$2.96 \cdot 10^{11}$
Portion of the release limit	5%	0.3%

a) The unit of radioactivity is Becquerel (Bq): 1 Bq = one nuclear transformation per second.

b) Iodine releases were under the detection limit. The detection limit for the most significant iodine isotope was about $1 \cdot 10^{6}$ Bq/month in Loviisa and about $3 \cdot 10^{6}$ Bq/month in Olkiluoto.

c) The numerical value shows the release limit for the plant site by nuclide group, assuming that other releases would not occur. The total release limit is calculated so that the sum of the various types of release limit shares does not exceed 1.

topes of manganese and silver (silver-110m, 10 observations and manganese-54, 7 observations). In some samples from the aquatic environment, also the following radioactive substances were detected: tritium (4 observations), cobalt-58 (1 observation). All the detected concentrations were low and have no bearing on radiation exposure.

Radioactive isotopes of strontium, caesium and plutonium (strontium-90, caesium-134 and 137, plutonium-238, 239 and 240), originating from the Chernobyl accident and the fallout from nuclear weapons tests, are still measurable in environmental samples. Natural radioactive substances (i.a. beryllium-7, potassium-40 and uranium and thorium with their decay products) are also detected whose concentrations in the samples in question are usually higher than those of radioactive nuclides originating from power plants or fallout.

Dosemeters measuring external radiation have been placed in the environment of Finnish nuclear power plants, in about 20 locations within a radius of 1–10 km from the plants as well as 25 continuously operating measurement stations within a 5-km radius from the plants. The measurement data yielded by the stations are transferred both to the plants' control rooms and the national radiation monitoring network. Monitoring is complemented by dose rate verification measurements and spectrometric measurements. In the environment of Loviisa plant, 10 such measurements verifying external radiation were made.

4.3 Olkiluoto nuclear power plant

4.3.1 Operation and operational events

Both units of Olkiluoto nuclear power plant operated reliably. The load factor of Olkiluoto 1 was 97.6 % and that of Olkiluoto 2 was 95.1%. The duration of the annual maintenance outage of Olkiluoto 1 was eight days and that of Olkiluoto 2 15 days. The measures taken during the outages are described in Appendix 5.

A reactor scram occurred at Olkiluoto 2 on 21 March 2001 in consequence of an operational transient on the turbine side. The event is described in more detail in Appendix 6. The annual maintenance outages were the only production breaks at the Olkiluoto plant units.

Production losses from component malfunctions were 0.01% at Olkiluoto 1 and 0.5% at Olkiluoto 2.

Fig. 9 gives the daily average gross powers of the plant units in 2001. Load factors and the number of reactor scrams over the past years are given in Figs. 10 and 11.

One event at the Olkiluoto plant units was INES Level 1. Weakened reliability of the system cooling the reactor in an accident situation had been observed at the Olkiluoto plant units, which was due to valve actuator gear tooth failures. Other events had no bearing on nuclear or radiation safety. The most significant events are described in Appendix 6. The total number of events at INES Level 1 and above at the Finnish nuclear power plant units is given in Fig 12.

4.3.2 Non-compliances with the Technical Specifications

At the Olkiluoto plant the following three events were in non-compliance with the Technical Specifications:

- Automation preventing reactor control rod withdrawal was bypassed at Olkiluoto 2
- Reactor control rod position data was unavailable in the control room of Olkiluoto 2
- In operability of two reactor feed water conductivity maeasurements at Olkiluoto 2.

Event descriptions are given in Appendix 6.

The licensee has planned, or already implemented, measures to prevent recurrence. Fig. 13 gives the number of non-compliances with the Technical Specifications over the past years.

The Technical Specifications were deviated from by virtue of exemptions granted by STUK. In 2001 STUK granted six such exemptions for the Olkiluoto plant units based on the licensee's application. The yearly number of exemptions is given in Fig. 14.

4.3.3 Event investigation

Teollisuuden Voima Oy clarified whether the number of plant events in non-compliance with the Technical Specifications could be reduced by measures recommended in a STUK research report completed in 2000. The piece of research in question is described in Annual Report 2000 (STUK-B-YTO 208) and the plant events deviating from the Technical Specifications in Annual Report 1999 (STUK-B-YTO 202).

Teollisuuden Voima Oy considered sufficient the procedures whose revision STUK had recommended. STUK considers them insufficient since events deviating from the Technical Specifications still occur and their number at Olkiluoto power plant has not been reduced. The handling of the matter with the licensee therefore continues. STUK has further requested a report on how the licensee will develop their change management procedures as well as their procedures for reducing excess routine in work and for improving the flow of information within their organisation.

4.3.4 Safety improvements

Modifications to improve safety at Olkiluoto power plant were based on the requirements of the YVL guides and on operational experience.

Modifications relating to severe accident management were continued at both plant units. The most important of them was the strengthening of the personnel lock of the Olkiluoto 1 containment. With this modification the pressure shock resistance of the containment in case of pressure shocks during severe accidents was improved. In addition, lye tanks were installed at the plant units to inject lye for containment water pH regulation. In this way iodine release from fuel to the environment during accidents is prevented as efficiently as possible.

Some modifications based on operational experience were also made at the plant units. These included replacement of the rod control and rod position indication system of control rods as well as of the measurement computer, and the replacement of rotating converters by UPS equipment. The fire detection system was also replaced.

The safety improvements are described in Appendix 7.

4.3.5 Probabilistic safety analyses

The updating of Level 1 safety analysis (PSA) for the Olkiluoto plant units was reviewed. Level 1 PSA assesses the probability of a reactor core melt.

The core melt frequency for the Olkiluoto plant units estimated in Level 1 PSA is ca. 2.0×10^{-5}/year. No single initiating event dominates the overall result even if the share of seismic initiating events is relatively high, i.e. 25%. A degree of conservatism is related to earthquake modelling, however, whose impact could not be assessed by this analysis. Another significant feature of the Olkiluoto PSA is that the share of annual maintenance outages of the core melt frequency is small, i.e. ca. 2%. This is partly due to improved guidelines and procedures and careful work planning during annual maintenance outages.

Accident risk at the Olkiluoto plant units is most effectively reduced by improved manual measures in switching on the power supply back-up from the neighbouring plant units' stand-up generators or in starting high pressure water back-up units during certain transients or in calibrating reactor water level measurements.

No disadvantages surfaced during the review of the updating of the PSA which would essentially have changed the analysis results or the conclusions made from them.

The review of the Level 2 PSA for the Olkiluoto plant units was completed. Level 2 assesses the volume of radioactive substances released from the reactor containment to the environment in consequence of an accident as well as related release probability. The PSA yielded a release frequency of ca. $5.5 \cdot 10^{-6}$/year (internal and external initiating events included).

No significant shortcomings were observed in the review of Olkiluoto Level 2 PSA. In the newest Level 2 PSA update, minor releases have been modelled more closely than before to make the model better suited for the comparison of various scenarios and for risk studies.

4.3.6 Radiation safety

The radiation doses of those who worked at Olkiluoto nuclear power plant in 2001 were below the annual limit of 50 mSv. The distribution of individual doses in 2001 is given in Table II. The highest individual dose at Olkiluoto nuclear power plant was 12.7 mSv. It was mostly received while working at Olkiluoto 1 and 2 during annual maintenance outages. No individual dose in 1997-2001 exceeded the 100 mSv dose limit applied to any 5-year period.

According to STUK guidelines the threshold for one plant unit's collective dose is 2.10 manSv, averaged over two successive years. The threshold value was exceeded in neither plant unit. In 2001 the collective occupational dose was 0.367 manSv at Olkiluoto 1 and 0.816 manSv at Olkiluoto 2, i.e. a total of 1.18 manSv for both plant units. Collective radiation doses for Loviisa and Olkiluoto power plants over the past years are given in Fig 15. Doses incurred during annual maintenance outages are described in Appendix 5.

Radioactive releases from Olkiluoto nuclear power plant into the environment in 2001 were well below authorised limits. The releases of gaseous radioactive effluents were 0.0004% of authorised limits. Radioactive iodine releases were below the detection limit. The tritium content of liquid effluents, 0.9 TBq, is ca. 5% of the annual release limit. The total activity of other liquid effluents was 0.9%, which is ca. 0.3% of the plant-specific release limit. Measured radioactive releases are given in Table III.

The radiation dose calculated for the most exposed individual in the environment of the plant on the basis of releases was ca. 0.05 µSv, i.e. 0.06% of the limit (100 µSv) established by a Government Resolution. Annual calculated radiation doses are given in Fig 16.

Environmental radiation monitoring around a nuclear power plant comprises on- and offsite measurements as well as determinations of radioactive substances to establish public exposure and radioactive substances present in the environment.

In the environment of Olkiluoto nuclear power plant, 300 samples were analysed in accordance with a monitoring programme. Radioactive substances originating in Olkiluoto plant were measurable in two samples of air, one sample of deposition, one sample of rain water deposited material, one sample of lichen, two samples of bottom fauna, one sea water sample and 16 samples of aquatic plants, 16 samples of sinking matter and one sample of soil. The dominating plant-based radioactive substance, cobalt-60, was measured in all of the aforementioned samples. The total number of observations was 38. In addition to cobalt, manganese-54 was measured in four samples of aquatic plants. An elevated tritium concentration was observed in one sample of deposited material.

All the detected concentrations were low and had no bearing of radiation exposure.

In addition, 14 measurements to verify external radiation were made in the environment of Olkiluoto nuclear power plant.

4.4 Fifth reactor in planning

Teollisuuden Voima Oy on 15 November submitted to the Government an application for a decision in principle on the construction of a new nuclear power plant unit. The application is for a unit equipped with a light water reactor, with an output of ca.1000–1600 MW, to be placed on either of the existing nuclear power plant sites. The application covers other nuclear facilities onsite relating to the plant unit's operation, i.e. for handling of fresh nuclear fuel, for intermediate storage of spent nuclear fuel, and for treatment, storage and final disposal of low- and intermediate-level reactor waste. Teollisuuden Voima Oy's application describes the seven types of light water reactor on offer.

On 8 February 2001 STUK submitted to the Government a preliminary safety evaluation on the new nuclear power plant unit and how it would meet current Finnish requirements for nuclear safety. The evaluation is based on the Nuclear Energy Act and was drawn up at the Ministry for Trade and Industry's request.

STUK's preliminary safety evaluation did not bring forth anything to suggest it would not be possible to bring the plant alternatives up to the Finnish safety standards. However, none of the offered facility concepts do, as such, meet all requirements. The character and scope of the necessary modifications considerably vary plant by plant.

According to STUK's evaluation nothing prevents the construction of a new plant unit on either of the existing plant sites. Radioactive releases from the new facility, combined with releases from those already in operation, would clearly remain below site-specific total release limits. Considerations expressed in statements on environmental impact assessment reports shall be taken into account, however, to assure a sufficient coolant water supply to the power plant.

In STUK's understanding, Teollisuuden Voima Oy should develop in the construction phase already its organisation, operation and technical expertise with a view to the design of safety-important systems to assure safe plant operation in a situation where no comprehensive safety design services are available on the market.

On the old plant sites nothing prevents the safe handling of low- and intermediate-level reactor waste generated during the operation of the new nuclear power plant unit. The facilities for the final disposal of low- and intermediate level waste can be enlarged in such a way that the safety of final disposal is not compromised.

The spent fuel generated by the new power plant unit Teollisuuden Voima Oy plans to dispose of in the same way as that generated by the operating plants, i.e. in a final repository in bedrock in a way reliably preventing the spreading of radioactive substances back to the biosphere for a sufficiently long time. STUK has reviewed the final repository for spent fuel in the preliminary safety analysis report of 11 January 2000 on Posiva Oy's application for a decision in principle.

In its application Teollisuuden Voima Oy notes that the final choice may well be some other light water reactor than the one in the application. STUK has followed nuclear engineering developments but how other types of light water reactor would meet Finnish safety requirements must be separately assessed, should such a choice become topical.

During February the Ministry of Trade and Industry arranged public hearings in the candidate municipalities in which STUK presented the Preliminary Safety Analysis Report.

After the terrorist attacks of September 11 on the United States STUK launched an investigation into the safety of domestic nuclear power plants in case of similar terrorist deeds.

A Supplement to the Preliminary Safety Evaluation, which made more specific safety requirements regarding aircraft impacts and other corresponding external threats, was submitted to the Ministry of Trade and Industry in January 2002.

The Preliminary Safety Evaluation and the Supplement can be found in STUK's Web pages at *http://www.stuk.fi/english/npp/5th_npp.html*.

4.5 Other nuclear facilities

FiR 1 research reactor

STUK regulates electricity-generating nuclear power plants as well as the FiR 1 research reactor operated by the Technical Research Centre of Finland (VTT). The reactor is located in Otaniemi, Espoo, and its maximum thermal power is 250 kW. The reactor is used for fabrication of radioactive tracers, activation analysis, student training and treatment of brain tumours by neutron irradiation (Boron Neutron Capture Therapy—BNCT) as well as development of BNCT therapy.

STUK's periodic inspections in February focused on the reactor's operation, emergency preparedness, training, radiation protection and measurements, radioactive releases, and nuclear waste storage and accounting, and in December on fire protection. No safety problems were observed.

The performance characteristics of the reactor's BNCT irradiation unit are good. In addition, VTT has investigated a power uprate test, with financing from Tekes, the National Technology Agency, to reduce irradiation time required for treatment. STUK has reviewed some related safety questions. VTT informed, however, that it will not implement the project in 2001.

The head of operation of the research reactor on 30 January 2001 noticed that the licences of the reactor's three foremen and two operators, granted by STUK, had expired on 31 December 2000. The reactor had been operated seven times in January. Each time the three foremen with expired licences had taken turns as heads of operation. The operators' licences had been valid. VTT arranged on 6 February 2001 a written exam for the approval of foremen and operators in which the above foremen participated. At VTT's request STUK approved of their continued working as foremen. The event has no bearing on safety since the persons in question were experienced workers. The event was classified INES Level 0.

Occupational radiation doses and radioactive releases into the environment in 2001 were clearly below set limits.

Nuclear waste management facilities

The regulatory control of nuclear facilities pertaining to nuclear waste management, such as storage space, is dealt with in Chapter 5.

5 Regulatory control of nuclear waste management

5.1 Spent nuclear fuel

STUK monitored the storage of spent nuclear fuel by regular inspections and by reviewing plans and witnessing work pertaining to storage equipment. No storage-related events occurred that would have endangered safety. The yearly volumes of spent fuel stored onsite are given in Figure 17.

Posiva Oy, a company owned by Teollisuuden Voima Oy and Fortum Power and Heat Oy, carries out R&D and planning into spent fuel disposal and prepares for implementation at a later date. The company in May 1999 submitted an application for a decision in principle on the construction of a final disposal facility in Olkiluoto. The decision in principle made by Government in December 2000 was ratified by the Finnish Parliament in May 2001.

The final disposal project's other main objects are to start facility construction in early 2010, with commissioning in early 2020. During the next 10 years, Posiva plans to implement an extensive research, development and design programme to assure site suitability and to obtain research data ensuring safe final disposal. This programme includes the construction of an underground research facility in Olkiluoto.

STUK gave an expert opinion on this action plan for final disposal, which was published by Posiva Oy in early 2001. STUK submitted its statement on the action plan to the Ministry of Trade and Industry in September. In addition to the opinions of own experts in the matter, STUK consulted six foreign experts. The Advisory Committee on Nuclear Safety, functioning in conjunc-

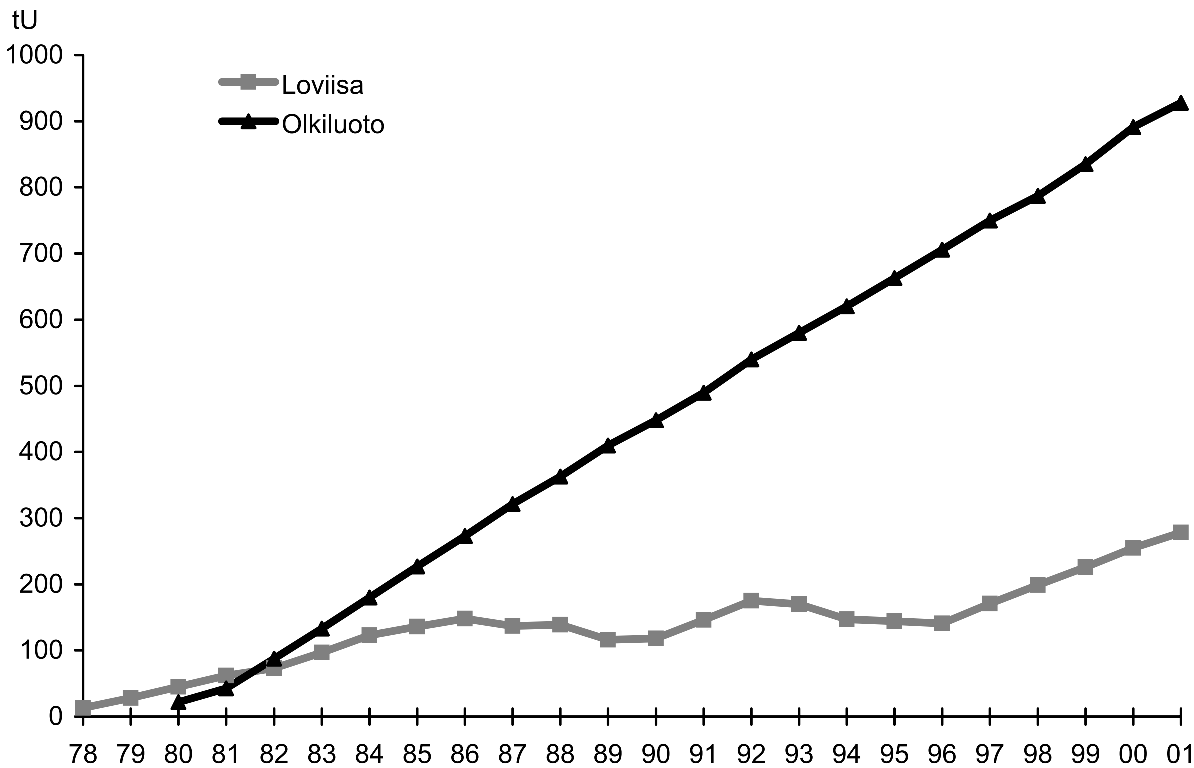

Figure 17. *The volume of spent nuclear fuel on plant sites at the end of the year.*

tion with STUK, submitted a statement to STUK.

STUK assessed as too tight Posiva Oy's timetable for reaching construction licence readiness. Even the first phase, the main objective of which is to complete determination of the baseline of the bedrock prior to the construction of an underground research facility, will take at least a year longer than planned. In addition, tests to be conducted in the underground facility and the development of encapsulation and final disposal technology may take longer than planned. However, STUK estimates as realistic the repository project main objective, i.e. readiness to commence final disposal in early 2020.

The main objective of Posiva Oy's geological research programme is to assure the suitability of Olkiluoto bedrock for final disposal. STUK assessed the programme as basically realistic but gave, at the same time, several possible further research topics for Posiva Oy to consider regarding features specific to the Olkiluoto bedrock in particular.

Posiva Oy is in the process of developing safety analysis methods and conducting safety research in preparation of a preliminary safety assessment required for inclusion in the construction licence application for the repository. STUK suggested some further objects of development and that Posiva Oy publish a detailed progress report in 2005 on its safety analysis development projects.

The underground research facility, whose construction in Olkiluoto will start in a few years, may later become part of an actual repository, a fact to be taken into account in the regulatory control of its implementation. STUK sent a letter to Posiva Oy in September concerning the objectives, procedures and allocation of regulatory control. The starting point being that STUK has to be able to form a real-time picture of questions essential for safety and relay it direct to Posiva.

Posiva Oy in 2001 continued its bedrock studies in Olkiluoto to establish the area's baseline and to support the designing of an underground research facility. The studies are overseen by four STUK follow-up groups whose members include domestic and foreign experts outside STUK.

In June 2001 Posiva Oy extended its co-operation agreement with the Swedish nuclear waste company SKB to include research, development and design relating to the encapsulation of spent fuel. Posiva thus acquired SKB's encapsulation know-how and the right to participate in large-scale test programmes in the Oskarshamn encapsulation laboratory in Sweden.

5.2 Reactor waste

Fortum Power and Heat Oy plans on the site of Loviisa nuclear power plant a solidification facility for medium level waste, since the plant's onsite storages for liquid waste are nearly filled to capacity. Plans are to treat at the solidification facility all liquid waste, such as ion exchange resins and evaporation waste, generated at the power plant. Even waste accumulating during the decommissioning of the plant will be solified in this facility. The waste will be medium- and low-level and it will be solidified in concrete.

The solidification facility in principle is a nuclear facility referred to the Nuclear Energy Act but requires no construction licence since the power plant's operating licence authorises STUK's approval of its construction as a plant modification referred to in Section 112 of the Nuclear Energy Act.

Fortum Power and Heat Oy submitted the solidification facility's Preliminary Safety Analysis Report to STUK for review in early 2000. The most important objects of the review were the solidification process proper, the waste package transfer system, occupational radiation protection and definition of the characteristics of solidification products. STUK made a safety assessment of the facility based on the review and in March 2001 approved the facility's Preliminary Safety Analysis Report.

STUK's safety assessment considers the solidification facility rather safe for the environment. The volumes of waste treated at a time are small and contain no hazardous amounts of gaseous or volatile radioactive substances. No high pressures or temperatures are required by the process and the facility contains no significant fire loads. Experiences of the operation of several corresponding facilities have been are good. The technical remarks issued on the basis of the review do not prevent the starting of the facility's construction.

As a result of the regular inspections concerning reactor waste management, STUK made remarks on i.a. the nuclear waste accounting system. The most important observation about the final disposal of reactor waste was that removal of leak water from the repository of Loviisa power plant had stopped for about a week because all pumps had broken. Several hundreds cubic meters of water had consequently flowed through overflow channels to the yet-uncompleted solidified waste hall from where it was later removed.

By STUK's permission, scrap metal, maintenance waste and waste oil from nuclear power plants were cleared from regulatory control. Licences issued by STUK are listed in Appendix 2.

No safety-related problems occurred in the treatment, storage and final disposal of reactor waste. Yearly waste volumes are given in Figure 18.

5.3 Other control activities

STUK gave to the Ministry of Trade and Industry a statement, as referred to in section 78 of the Nuclear Energy Decree, about the licensees' nuclear waste management measures and plans as well as a statement, as referred to in section 90 of the Nuclear Energy Decree, about making financial provision for the costs of nuclear waste management. These regular statements assess whether, in preparing for nuclear waste management, the licensees have proceeded according to goals set out by the government. At the same time, provision made for the future cost of nuclear waste is being assessed.

Bonvesta Oy in 1992-1995 carried out some remedial actions in the former uranium mine area of Paukkajavaara, which were overseen by STUK. The measures were followed by a surveillance period of about five years. On the basis of inspections and measurements STUK ascertained that mining wastes had been successfully isolated and that no elevated concentrations of radioactivity deviating from the environment and originating in the disposed waste were measurable. STUK issued Bonvesta Oy a certificate, in accordance with Section 84 of the Nuclear Energy Decree, attesting to the acceptability of the final disposal.

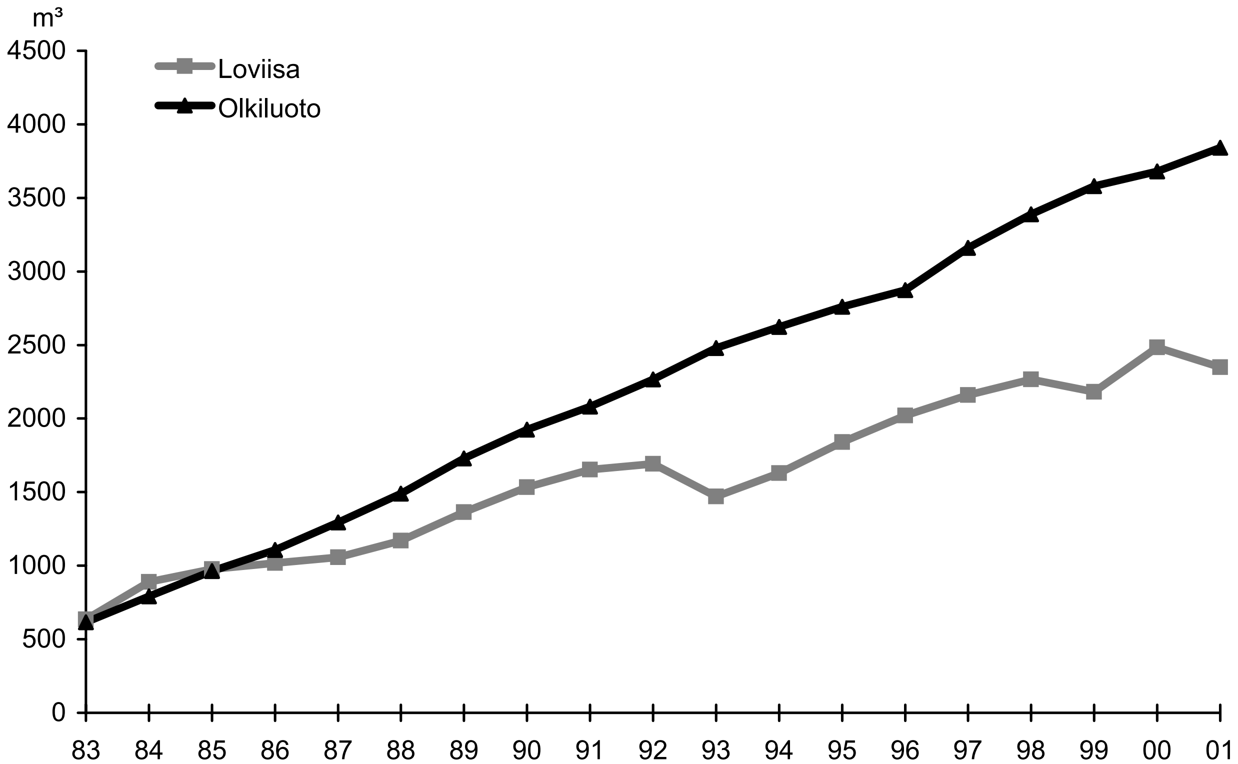

***Figure 18**. The volume of reactor waste at the end of the year.*

6 Regulatory control of nuclear materials

6.1 Safeguards at Finnish nuclear facilities

As regards nuclear power plants, STUK's safeguards focused on the import, storage, domestic transfer and reloading of fuel. The licensees submit to STUK the necessary annual plans, advance notices and reports in compliance with safeguards requirements

In 2001 the number of safeguards inspections at Loviisa nuclear power plant was 10 and at Olkiluoto nuclear power plant 16. Euratom Safeguards Office (ESO) participated in 16 and the IAEA in 19 inspections. ESO used 30 and the IAEA 22 man-days. Both reactor units of Loviisa nuclear power plant, the fresh fuel storage and the two spent fuel storages comprise one unit in nuclear material accounting, i.e. a material balance area. Olkiluoto nuclear power plant has three material balance areas: Olkiluoto 1, Olkiluoto 2 and a spent fuel storage.

STUK verified by NDA measurement 53 spent fuel assemblies at Olkiluoto nuclear power plant. At Loviisa nuclear power plant, 96 spent fuel assemblies were verified. Safeguards employs several verification methods to verify that the nuclear materials data given by the users, such as burnout and cooling time, are correct and complete. Even other matters relating to nuclear safety, ranging from operational safety to final disposal, can be verified by measurements.

In addition to the domestic nuclear power plants, minor amounts of nuclear material can be found at other facilities. The most significant of these is FiR 1, the research reactor operated by the VTT. Also the Laboratory of Radiochemistry at the Department of Chemistry of the University of Helsinki and STUK possess small amounts of nuclear materials. In 2001 two inspections were conducted on FiR 1.

International safeguards is implemented by the IAEA and ESO. IAEA safeguards are based on the Non-Proliferation Treaty and the Safeguards Agreement signed by non-nuclear EU member states, Euratom and the IAEA (INFCIRC/193). ESO safeguards are based on the Euratom Treaty and Commission Regulation 3227/76 given by virtue of the Treaty. STUK participated in inspections carried out by international organisations.

ESO and the IAEA have agreed on co-operation in the field of inspections (New Partnership Approach, NPA). At practical level, ESO and the IAEA co-operate in the conducting of inspections in all material balance areas. ESO conducts periodic inspections at Olkiluoto 1 and 2 but inspections of the KPA storage, which are made at the same time, have participants from both ESO and the IAEA.

Operation in all material balance areas was in accordance with manuals approved by STUK, facilitating the implementation by STUK of the obligations of international nuclear agreements signed by Finland. In 2001 ESO and the IAEA delivered to STUK 18 joint reports consisting of ESO inspection reports and IAEA reports. According to the reports national obligations had been fulfilled in compliance with INFCIRC/193.

After the disclosure of the Iraqi nuclear weapons programme, the IAEA launched an extensive programme to strengthen the safeguards system. This overall safeguards renewal is based on the commencement of safeguards based on the Model Protocol Additional (INFCIRC/540) as well as the integration of "old" (in accordance with the Safeguards Agreement) and "new" safeguards (in accordance with the Model Protocol Additional). Finland ratified the Protocol on 30 June 2000. It will come into force in all non-nuclear EU member countries simultaneously. Italy and Belgium, among others, had not yet in 2001 ratified the Model Protocol Additional. STUK, IAEA and ESO have tested safeguards implementation in accordance with the Protocol in a field test at VTT Chemical Technology. As the most important result of the test, the flow of information concerning data referred to in the Protocol was described and the roles and responsibilities of those participating in regulatory work were determined.

In 2001 STUK authorised eight ESO and 26 IAEA inspectors to inspect domestic nuclear facilities.

The report STUK-B-YTO 213 (in Finnish) takes a closer look at safeguards.

6.2 Control of radioactive materials transport

About 20 000 radioactive packages are transported in Finland every year. STUK is not aware of any transport accidents involving radioactive materials, or of any other safety hazards.

The transport of nuclear materials requires a licence from STUK. A prerequisite for the licence is, among other things, that nuclear liability insurance and sufficient physical protection are in place. In 2001 STUK granted one nuclear transport licence to Fortum Power and Heat Oy for the importation and exportation of fresh fuel. STUK approved four transport plans for the importation of fresh fuel. STUK approved one package type for use in Finland. The most important forms of nuclear material transport in 2001 were imports of fresh nuclear fuel (a total of 430 fuel assemblies) from Germany, Spain and Russia as well as two fresh fuel rods from Germany for use at Finnish nuclear power plants.

The importation of radioactive and nuclear materials is subject to licence, too. No attempts at nuclear smuggling were observed at the Finnish borders in 2001.

In 2001 no shipments containing radioactive material were turned back at the border. The highest number, 23 consignments, was turned back in 1997. The number is smaller now than in previous years, partly because consignors and consignees have, through training and experience, come to understand the possibility of radioactivity in consignments of scrap metal. Control at the borders has been enhanced and, at the same time, consignments of scrap metal to Finland have decreased and goods arriving from Russia to Finland have already passed Russian radiation measurement control.

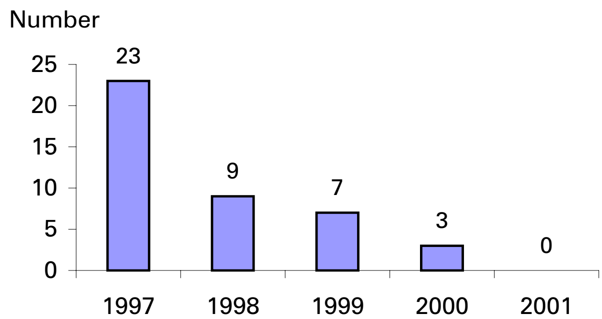

Figure 19. *The number of consignments containing radioactive materials turned back at the border.*

7 Safety research

STUK's experts controlled and monitored the ongoing, publicly financed national nuclear power plant safety and waste research programmes FINNUS 1999–2002 and JYT2001. STUK commissioned nuclear power plant safety and waste management research to external organisations, which in 2001 were as follows: VTT Automation, VTT Chemical Technology, VTT Energy, VTT Industrial Systems, VTT Processes, VTT Building and Transport, the Geological Survey of Finland (GSF), the Finnish Institute of Marine Research (MTL), TKK Laboratory of Theoretical and Applied Mechanics, TKK Laboratory of Physical Metallurgy and Materials Science, Helsinki University Laboratory of Radiochemistry, Uppsala University, St Petersburg State University, University of Aberdeen, University Polytechnic of Catalonia, NEMKO Product Services and Serco Assurance (formerly AEA Technology plc) Inspection Validation Centre (IVC).

The research topics of the FINNUS 1999-2002 programme in 2001 were nuclear power plant ageing, reactor accidents and various risks. The programme is arranged into eleven research projects whose data, such as results, costs and hours spend, are available at *http://www.vtt.fi/ene/tutkimus/finnus/*. The FINNUS programme annual report can be found at the same web address.

In 2001, 35 nuclear power plant safety projects commissioned and financed by STUK were launched. They included reference analyses and reports as well as studies aiming at enhancement of inspection and analysis readiness in nuclear power plant structural and reactor safety as well as in safety management. In the field of reactor safety, STUK contributed to the following five international research programmes: NRC/CAMP and CSARP; OECD/SETH, LHF and MASCA. In addition, projects to improve the regulatory control effort were started.

The research topics of the JYT2001 programme in 2001 were the same as before, i.e. earth sciences, technical barriers, migration of radioactive substances, safety analyses and technical solutions. The JYT2001 programme has also included research topics in social sciences. The programme's final report is due in early 2002 in a Ministry of Trade and Industry publication series called research and reports. Information on the programme can be found at *www.vtt.fi/ene/tutkimus/jyt2001* (in Finnish).

Appendix 4 lists STUK-financed safety research completed in 2001. Part of it closely relates to nuclear safety regulation and is presented in a group of their own, separatly from the FINNUS and JYT programmes. STUK's research programme includes projects dealing with the development and assessment of operational inspections and review. The annual cost of nuclear safety research is given in Fig 20.

Topical nuclear safety research and publications are reported in STUK's web pages at *www.stuk.fi/tutkimustoiminta/* (in Finnish). The current number of projects is as follows: 47 research projects into nuclear safety and 36 research projects into the safety of nuclear waste management.

To assure the independence of nuclear power plant safety research STUK commissioned to an external consultant follow-up audits of the quality systems of two of VTT's research units. An external consultant audited also the quality system of the Geological Survey of Finland (GSF). The results of the audits were reported in feedback meetings arranged by STUK to persons responsible for quality in the organisation units in question and to STUK's respective persons in charge of nuclear safety research.

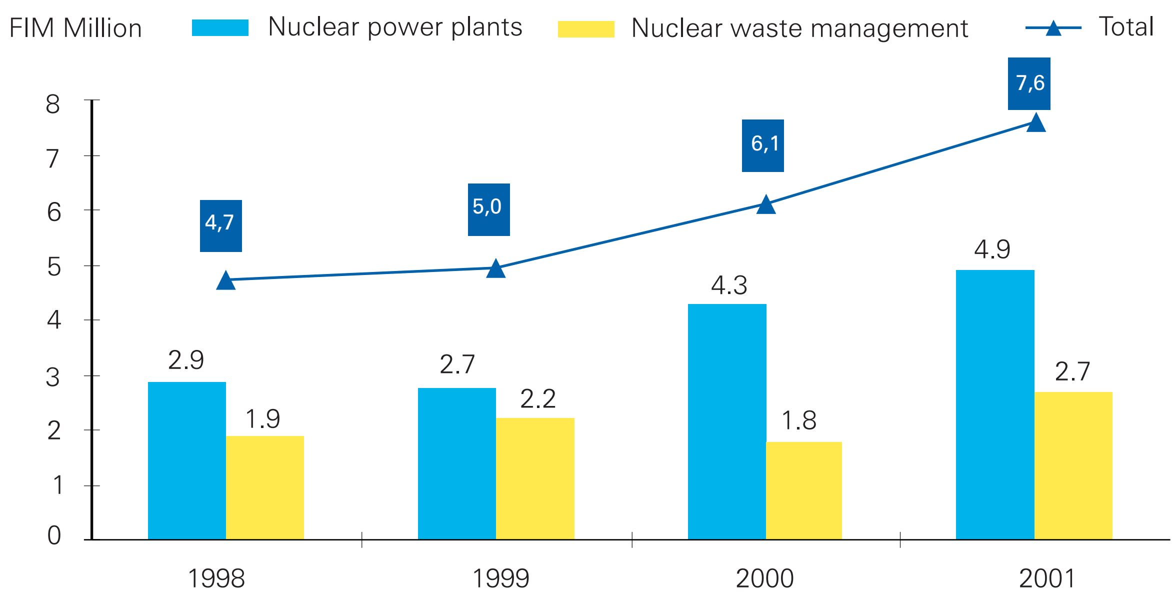

Figure 20. *The costs of nuclear safety research.*

8 Emergency response

STUK arranged several training events and excercises to test and develop its emergency response. Emergency training was arranged for experts from foreign authorities. In addition, STUK controlled the preparedness of the operating organisations of nuclear power plants to act in unusual situations. No such situations occurred in 2001.

Various types of emergency exercises were arranged in Finland in 2001 into which STUK participated. An emergency exercise and training event was arranged in Rauma town on 5 September 2001 concerning Olkiluoto power plant. Representatives of the licensee and several authorities participated. Loviisa power plant's emergency exercise was on 28 November 2001 and STUK participated in it in accordance with the emergency plan. In addition, emergency response at the FiR 1 research reactor was tested on 25 September 2001. A fire drill was arranged at Loviisa power plant on 2 May 2001. Olkiluoto power plant's fire drill was on 19 November 2001.

Emergency response at nuclear power plants has been continuously developed during plant operation and regularly tested in emergency exercises as part of emergency preparedness training. STUK has approved the emergency plans of Loviisa and Olkiluoto nuclear power plants and reviews every year the implementation of the emergency preparedness regime, including training and emergency excercises.

STUK participated in nuclear power plant emergency exercises of international scale. The JINEX-1 emergency exercise was arranged in France on 22–23 May 2001 with 55 countries and five international organisations taking part. The exercise, which lasted for over 24 hours, tested the flow of information and the methods of passing information as well as the forming an overall picture of the accident situation, and decision-making. The long-duration exercise facilitated also a shift change. International data exchange was of foremost importance also during the Swedish ALEX emergency exercise on 28 March 2001, which was part of an extensive Barents Rescue exercise.

9 Communications

STUK took the initiative in communicating to the general public matters relating to the safety, nuclear waste management and safeguards at nuclear power plants and also responded to questions made by the media. STUK issued bulletins or press releases on almost 20 different topics. The material was also published on the Teletex pages of YLE (Finnish Broadcasting Company) and on its own Web site. In addition, the matters were discussed in the STUK publication ALARA that comes out four times a year. The media and liaison groups were provided with quarterly reports on the nuclear safety in Finland and in its neighbouring countries.

A reader survey was conducted to establish how interesting readers find the contents of the quarterly report on nuclear safety. With the report on the first quarter of 2001, a questionnaire was sent to over 400 regular report recipients, 31% of which replied. The recipients were asked how closely (closely/ occasionally/ not at all) they follow the report's various sections. The degree of interest in the various sections was assessed based on the number of people saying they closely followed the section in question. The most closely followed section was thus that on emergency preparedness, which 52% of the readers said they followed closely. The next most read sections were those on Loviisa nuclear power plant and on nuclear power plants in Finland's neighbouring countries (46% and 45%). Next came Olkiluoto nuclear power plant and the regulatory control of nuclear power plants (39% and 41%). 32% told they followed nuclear waste management and 21% expressed interest in nuclear safeguards. In addition, the survey mapped the need for a hard copy of the report now that it is available at STUK's Web page. 76% of those who replied wanted a printed version of the report by mail.

On STUK's Web site, under The Reader's Link, citizens made questions to STUK's experts. In 2001, 250 questions were made 5% of which were about the use of nuclear energy.

Of the events at Finnish nuclear power plants, the media were informed about a leak of mildly radioactive water during the annual maintenance outage of Loviisa plant as well as valve actuator malfunctions in the emergency coolant system of the Olkiluoto plant units. The plant units' annual maintenance outages and brief production breaks were reported. Brief production breaks were caused by reactor scrams at Loviisa 1 and Olkiluoto 2 and repair outages of which there were one at both Loviisa units.

As regards nuclear waste management, STUK provided information about a review report submitted to the Ministry of Trade and Industry. This review report addressed the research, development and technical design programme for spent nuclear fuel disposal, prepared by the nuclear waste company Posiva Oy. As regards nuclear material safeguards, a summary report was issued on radioactive shipments turned back at Finland's eastern border in 2000.

In connection with projects to improve nuclear safety in countries in Eastern Europe, information was disseminated, among others, about a new safety system installed at Kola nuclear power plant and a meeting in St Petersburg dealing with safety analyses made for the Leningrad nuclear power plants as an international project. The Kursk submarine lifting operation was reported as well.

Information was published about issues relating to international co-operation, i.a. a nuclear safety report submitted to the IAEA based on the International Nuclear Safety Convention, the International Nuclear Waste Convention, meetings hosted by STUK, nuclear safety regulation in the EU applicant countries and STUK's participation in an international nuclear emergency exercise.

10 International co-operation

Co-operation with the IAEA

STUK prepared to the IAEA several statements requested from Finland (see Appendix 3) on draft guides belonging to an ongoing revision of the IAEA's nuclear safety and nuclear waste management regulations (NUSS and RADWASS). The revision is nearing completion. STUK participated in the preparation of the draft guides. STUK also participated in the work of the permanent NUSSC and WASSC committees guiding the work on the guides.

A report, whose submission is required every three years in the International Nuclear Safety Convention, was sent to the Convention Secretariat at the IAEA in autumn 2001. It describes how the Convention's obligations have been met. The next review meeting is due in 2002.

The Joint Convention on the safety of spent fuel and radioactive waste management took effect on 18 June 2001. STUK in December 2001 participated in the preparatory meeting of the Convention's first review meeting where rules of procedures and financial rules, practical meeting arrangements and the contents of national reports were agreed upon.

Also in 2001, a representative of STUK continued to function as one of the advisors (SAGSI) to the Director General of the IAEA in safeguards matters. The group met four times in 2001 and mostly discussed an overall safeguards reform.

Via the nuclear power plant Incident Reporting System (IRS), maintained by the IAEA and the OECD/NEA, 85 reports were received. By means of the system, nuclear power plant operational events and observations, which may give an impulse to safety improvements at other nuclear power plants, are communicated to the participating countries. STUK is the co-ordinating organisation in Finland. The database is on a CD, which is updated four times a year and accessible in Finland to STUK and the licensees. The IAEA is in the process of developing an Internet-based database for the recording and accessing of event data. IRS reports were assessed by STUK and the licensees. The reports analysed in 2001 did not warrant significant changes in the plant structures or operational practices at Finnish nuclear power plants. The procedures in use at Finnish plants were reviewed due to some events. Finland reported to the IRS system a common-cause failure of motor-operated reactor core spray system valves at Olkiluoto nuclear power plant caused by failures and cracks in the bakelite gear teeth of valve actuators. The event is described in Appendix 6.

STUK is also a contact organisation in an information exchange system maintained by the IAEA for the events at research reactor facilities (Incident Reporting System for Research Reactors—IRSRR). The system started operation some years ago and there were 31 participating countries at the end of 2001. An Internet-based database is under development for use in the system. For this purpose events at the research reactor over the past years have been collected. Data communication to countries in the system has so far mostly taken place at the system's annual meetings. In 2001 no events reportable to the system occurred in Finland.

The IAEA communicated through the INES information exchange system (International Nuclear Event Scale—INES) information on 26 events, 16 of which dealt with nuclear power plants and ten with the use of radiation sources. None of them were above INES Level 2. A required reporting criterion is that events are at least Level 2, or above, on the INES Scale or are, or may be, of interest internationally. A system called Nuclear Event Web-based System (NEWS) was commissioned for event data transmission.

Access rights to the system are held by 18 individuals in Finland who represent five organisations (STUK, Ministry for Trade and Industry, Fortum Power and Heat Oy, Teollisuuden Voima Oy, State Technical Research Centre). When event data has been entered into the system by a contact person those with access rights immediately receive the information. The Finnish INES contact person is from STUK. No INES reportable events occurred in Finland in 2001.

A representative of STUK worked as a co-ordinator to East and Middle European assistance programmes funded from the IAEA's safeguards support programme. The Ministry for Foreign Affairs finances the programme that is executed by STUK. The programme objectives include development of the IAEA's safeguards procedures, training of inspectors and provision of expert assistance.

In IAEA expert capacity, STUK's representatives participated in the IRRT assessment of nuclear safety authorities in Lithuania and the Czech Republic. A representative of STUK has also participated, as an IAEA expert, in work that compares the fuel design criteria of Russian VVER reactors with that of Western pressurised water reactors. The final report contains the comparison material and recommendations for further action.

Co-operation with the OECD/NEA

International co-operation in nuclear safety research was mostly channelled through the OECD/NEA. The organisation also facilitated an exchange of opinions between authorities about the need to develop nuclear safety regulations and the contents of individual regulations. STUK was represented in all of the organisation's main committees dealing with radiation and nuclear safety. The main committees are as follows:

- Committee on the Safety of Nuclear Installations—CSNI,
- Committee on Nuclear Regulatory Activities—CNRA,
- Committee on Radiation Protection and Public Health—CRPPH, and
- Radioactive Waste Management Committee—RWMC.

STUK's Director General acted as the chairman of the CNRA. In addition, STUK took part in the work of the below working groups set up by the committees.

In early 2001 the CNRA had only one permanent working group looking at regulatory safety inspection practices, namely the Working Group on Inspection Practices (WGIP). The group's work focused on the gathering, exchange and assessment of regulatory inspection practices as well as on the publication of commendable practices. It assembled twice, once in STUK. The WGIP published six reports about the strengthening of the regulatory effort to ensure the safe operation of nuclear facilities, e.g. about effectiveness of inspections and about inspection of preventive maintenance on safety systems during plant operation, among others. In addition, a report about regulatory inspection practices in OECD member countries and non-member countries was updated. The status report provided insights into the framework of inspection philosophies, organisational aspects and practices utilised within these counties Under preparation were reports about the supervision and inspection of the work of subcontractors, as well as the inspection of research reactors and other facilities contributing to the nuclear fuel cycle. Proceedings were published of a 2000 WGIP seminar, the fifth in line in a series of International Workshops, dealing with radiation protection inspections and regulatory inspections required during and after shutdowns as well as the use of objective indicators by authorities in evaluating of the performance of plants.

The CNRA set up a new permanent working group, the Working Group on Public Communciation of Nuclear Regulatory Organisations (WGPC) whose first meeting was in 2001.

There are six CSNI working groups into whose work STUK contributed, namely:

- Working Group on Operating Experience (WGOE)
- Working Group on Integrity of Components and Structures (IAGE)
- Working Group on Accident and Analysis (GAMA)
- Working Group on Risk Assessment (WGRISK)
- Special Expert Group on Human and Organisational Factors (SEG HOF)
- Special Expert Group on Fuel Safety Margins (SEG FSM).

Co-operation with the EU

The Atomic Questions Group (AQG), under the Council of Ministers of the EU, in spring 2001 set up an ad hoc working group to prepare a report on the status of the nuclear safety in the EU applicant countries. All EU member countries participated in it. The EU applicants Bulgaria, the Czech Republic, Hungary, Lithuania, Rumania, Slovakia and Slovenia use nuclear power. The Finnish representative in the working group was from STUK which has particular expertise in the situation of countries operating VVER reactors, i.e. Bulgaria, the Czech Republic, Hungary and Slovakia. The working group prepared a report about the status of nuclear power plants in each applicant country and about questions relating to other nuclear facilities, such as fuel and waste stores, and radiation safety. The report outlines the “high level of nuclear safety” required of the applicants and presents applicant-specific recommendations for the reaching of this level. The report was completed in May 2001 and the autumn 2001 has been reserved for replies. A corresponding working group will be set up to assess the replies in spring 2002.

STUK participated in the work of the following EU working groups: Nuclear Regulators Working Group (NRWG), European Radioactive Waste Regulator’s Forum (ERWR) and European Nuclear Installations Group (ENIS-G).

STUK contributed to the work of the NRWG Task Force on Non-Destructive Testing Qualification Programmes. The group has been assigned the task of exchanging authority experiences on the implementation and development of qualification in various European countries and to follow and assess the second pilot study conducted by the ENIQ, European Network for Inspection Qualification, with the regulator’s point of view in mind. To exchange experiences the group has drawn up a member survey. Plans are to report the results in spring 2002. Observers were appointed to monitor the second pilot study by the ENIQ. Intensive and active participation is aimed at by giving feedback to the ENIQ project group from a regulatory angle. In addition, STUK participated in the work of the NRWG Safety Critical Software working group.

In the field of nuclear material safeguards, STUK participated in the operation of the European Safeguards R&D Association (ESARDA). ESARDA’s duty is to promote and harmonise European R&D relating to nuclear material control. ESARDA offers a forum for information and ideas exchange to authorities, researchers and nuclear power plant operators.

NKS co-operation

The Nordic nuclear safety research programme NKS 1998–2001 covered three main areas: nuclear safety, emergency response as well as nuclear threats and dissemination of information; these were divided into seven projects. STUK’s representatives participated in several of them, assuming functions that were in part tasks and seminars. The most essential nuclear safety projects concered safety analyses, quality assurance and severe accident investigation.

The programme results were generally of good quality and scope. They were controlled by project managers, the NKS Secretary General and a steering group consisting of representatives from various countries and parties. STUK was represented in the steering group.

The new programme of NKS, to be launched in 2002, was planned. According to the plans the programme will be directed by two responsible programme managers instead of the former seven project managers. STUK headed planning of the new programme’s sub-area concerning reactor safety and participated also in the planning of the emergency preparedness and environmental safety programme.

Bilateral co-operation

A representative from STUK was an invited member of the Reactor Safety Committee assisting SKI. A representative of SKI was an invited expert in the Advisory Committee on Nuclear Safety that functions in conjunction with STUK. Co-operation with SKI was continued with regular meetings during which current questions of the regulatory control of nuclear power plants were discussed. Information exchange with the Swedish radiation safety authority (SSI) was continued concerning doses to Finns who had worked at nuclear power plants in Sweden and to Swedes who had worked at Finnish plants. Liaison in emergency situations was developed in co-operation with SKI and the SSI.

A representative of STUK acted as chairman of an international nuclear safety committee supporting the Belgian nuclear safety authority and participated as a permanent member in the work of a corresponding Lithuanian advisory committee.

STUK's co-operation with the USNRC focused on information exchange in nuclear safety matters of interest to both parties. A co-operation project was started between STUK, the USNRC and VTT to improve the thermohydraulics of the FRAPTRAN code for fuel transients by coupling with it a new thermohydraulic code called GENFLO. The USNRC and STUK signed a co-operation agreement defining the conditions of further programme development. Towards the end of 2001 a representative of STUK went to to work with the USNRC as a visiting expert.

STUK continued co-operation with the French nuclear safety authority regarding probabilistic safety analysis (PSA) and fire risks. The topics of co-operation were development of the PSA programme, fire risk analysis, PSA Level 2, PSA-based event analysis, emergency operation procedures and harsh weather risk analysis. Fire initiation related statistical data and fire modelling related research data was obtained from France.

Co-operation between STUK and the Swiss nuclear safety authority (HSK), closely related to probabilistic safety analysis (PSA), was continued. HSK has in use STUK's PSA code, among others. Experiences were exchanged in i.a. code development, PSA-based event analysis and risk-assessed inspection. The topics of co-operation included also quality assurance in regulatory activities and final disposal of nuclear waste.

Co-operation between STUK and the Russian nuclear safety authority (GAN) in the field of nuclear material and waste control continued based on a co-operation arrangement signed in 1998.

Safeguards co-operation between STUK and the Australian Safeguards and Non-proliferation Office (ASNO) was continued. STUK provided ASNO with information about nuclear materials imported to and kept in Finland.

Assistance to Central and Eastern European safety authorities

STUK continued to participate in the assistance given to radiation safety authorities in Central and Eastern Europe under financing from the Ministry for Foreign Affairs and the European Union as well as from the IAEA.

STUK carries out EU assistance programmes in association with other EU countries. The follow-on phase of projects in support of nuclear safety authorities were launched in Russia and Ukraine in 2001. Both are one-year projects. A project concerning the commissioning of RODOS software, serving the needs of decision-making in emergencies, was completed in Hungary. STUK was responsible for planning the project training programme. In Lithuania STUK, in co-operation with the Swedish radiation safety authority (SSI), prepared a PHARE Twinning project to assist the Lithuanian radiation safety authority in bringing practical radiation protection control up to the level required by EU regulations.

STUK maintained bilateral co-operation programmes with the nuclear safety authorities of Russia, Estonia, Latvia, Lithuania and Ukraine with funding provided by the Ministry for Foreign Affairs for co-operation with neighbouring areas. STUK maintained close contacts with the resident inspectors at Leningrad and Kola nuclear power plants who regularly prepared semi-annual reports on plant events, reporting to STUK the situation at the plants in question during their visits to Finland. In addition, the resident inspector of Leningrad nuclear power plant became acquainted with the Finnish qualification procedures for nuclear plant operators as well as the training programmes for operating personnel, the regulatory control of plant modifications and the project to develop the emergency instructions of Loviisa power plant.

In the field of safeguards, STUK closely co-operated with Russia, Estonia, Latvia, Lithuania and Ukraine. It provided training to coast guards and customs officials and equipment for the detection of radioactive materials to help reduce the smuggling of radioactive materials.

Enhancement of safety at East European nuclear facilities

STUK administered Finnish-Russian co-operation in the field of radiation and nuclear safety, funded from the Finnish government's budget for co-operation in neighbouring areas. Kola and Leningrad nuclear power plants as well as various radioactive waste storages are the objects of co-operation. STUK plans the projects together with the recipients, invites tenders and monitors the progress of the projects. In addition to the work carried out by consultants, STUK's experts actively participate in safety improvements at the plants.

These projects are a continuation to a long-term programme that emphasises the quality of plant operations, fire safety and the integrity of safety-relevant piping as well emergency response and environmental radiation monitoring.

Further information on the projects can be found in the report "Finnish Support Programme for Nuclear Safety, Bi-Annual Summary 2001" and also in the corresponding report "Annual Summary 2001" to be published in early 2002.

STUK's representatives worked in expert groups of the EU and the European Bank for Reconstruction and Development (EBRD), which assessed the appropriateness of nuclear safety improvement projects for which financing is sought. In support of the Ministry for Foreign Affairs STUK assigned, if necessary, an expert to the council meetings of the EBRD's nuclear safety funds.

In co-operation with GAN and the Radon combine, STUK continued the implementation of programmes involving the exchange of nuclear waste management information and experiences.

Additional monitoring instruments have been installed in the environment of the Kola plant. The radiation monitoring network there now has 15 automatic measurement stations.

STUK co-operated with the emergency centre in St Petersburg that is subordinate to the Russian ministry of energy. In 2001 STUK participated i.a. in the procurement of a ventilation system to the emergency centre's new premises.

The Comprehensive Nuclear Test Ban Treaty (CTBT)

A National Data Centre (NDC), which operates in conjunction with STUK, is based on the Comprehensive Nuclear Test Ban Treaty. The Centre contributed to the work of the preparatory commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) to establish a cost-effective and (from a Finnish viewpoint) functional organisation. It trained other national data centres to manage observation of the basic signs of nuclear test activities. In addition, it trained those attending to radiation monitoring stations to assure the operation of the stations. The NDC's own automatic, routine monitoring was in operation for the whole year. The NDC observed no abnormal activity in 2001.

Finland ratified the CTBT on 15 January 1999. In Finland STUK was assigned the duties of a National Data Centre, i.e. responsibility for the verification obligations of the treaty binding the national authority, i.e. the Ministry for Foreign Affairs and the international authority, and the international authority, i.e. CTBTO. The National Data Centre officially opened on 4 October 1999.

Other forms of co-operation

STUK participated in the work of the Western European Nuclear Regulators' Association (WENRA). STUK's contribution focused on the work of the "working group on harmonisation". The group has been mapping the harmonisation of the EU countries' nuclear safety regulations. Country-specific self-assessments were completed in 2001 on the basis of which the group made a comparison of the fulfilment of nuclear safety "reference requirements" in the EU countries. It had earlier drawn up a report on the reference level for nuclear safety requirements to be pursued in the EU countries.

STUK participated in the work of the Network of Regulators of Countries with Small Nuclear Programmes (NERS). NERS is a co-operation forum where the authorities of small nuclear countries (Argentine, Belgium, the Czech Republic, Finland, Hungary, the Netherlands, Slovakia, Slovenia, South Africa, Switzerland) exchange experiences on the special features of regulatory efforts relating to small-scale nuclear programmes. The specific topics of discussion in 2001 were consideration of the public in the use of nuclear energy, the maintenance of nuclear safety competence of small countries, safety indicators and radioactive waste treatment. NERS held one meeting in 2001.

The VVER Forum, a form of co-operation among countries operating VVER-type nuclear facilities, had four working groups in 2001 and STUK participated in three of them. The working group on inspection routines visited Khmelnitsk nuclear power plant in Ukraine. Joint inspections facilitate the practical comparison of inspection procedures and methods used by the authorities of countries operating VVER facilities. The main objects of inspection at Khmelnitsk were fire safety arrangements, plant operational safety and training activities. In STUK's contribution the checking of fire safety arrangements was emphasised. The working group on component ageing management drew up a report about the regulatory experiences gained on steam generator tube integrity and ageing as well as on preliminary projects pertaining to the operation of the prestress function of VVER 1000 containments. Loviisa nuclear power plant contributed to the preparation of the report. The working group made some proposals for use in service life managment follow-up work. A third working group into whose work STUK participated dealt with regulatory independence. The VVER Forum had also a working group on accident management operating in 2001.

The operation of the Loviisa Energy Centre (LEC) was terminated in 2001. The last meeting of the DOCUM project, launched at the LEC's initiative, and whose objective was to develop regulations for the management of the service life of nuclear facilities, was held in late 2000 and project follow-up work was agreed upon. In early 2001 STUK and the Russian International Nuclear Safety Centre (RINSC) prepared summaries of national regulations and practices. DOCUM meetings planned for 2001 were not held and the project's future is unclear due to the termination of the LEC.

11 The advisory committee on nuclear safety

In accordance with section 56 of the Nuclear Energy Act, the preliminary preparation of matters related to the safe use of nuclear energy is vested with the Advisory Committee on Nuclear Safety. The Government appoints the Committee that functions in conjunction with STUK. The term of office is three years. The current term of office ends 15 August 2003.

The Committee's Chairman is Professor Pentti Lautala (Technical Research Centre of Finland—VTT) and its Vice-Chairman is Head of Research Rauno Rintamaa (VTT) and the members are Senior Researcher Riitta Kyrki-Rajamäki (VTT), Professor Ulla Lähteenmäki (MIKES), Director Olli Pahkala (Ministry of the Environment), Professor Rainer Salomaa (Helsinki University of Technology), Branch Manager Paavo Vuorela (Geological Survey of Finland). Professor Jukka Laaksonen, Director General of STUK, is a permanent expert to the Committee. Invited experts are Doctor of Technology Antti Vuorinen and Director Christer Viktorsson of the Swedish Nuclear Power Inspectorate.

STUK received several statements from the Committee. The topics were the application for a decision in principle concerning the fifth reactor in planning; the nuclear waste solidification facility planned in Loviisa; Posiva Oy's research, development and design programme for the final disposal of spent nuclear fuel; and the national report to be issued on account of the International Nuclear Safety Convention. In addition, the Committee gave its opinion to STUK on several YVL guides, followed operational events at Finnish and Swedish facilities and made a fact-finding tour of Loviisa nuclear power plant. It convened 13 times during 2001.

The Committee has three divisions for preparatory work: a Reactor Safety Division, a Nuclear Waste Division as well as an Emergency Preparedness and Nuclear Material Division. In addition to the Committee members proper, distinguished experts from various fields have been invited to the Divisions. A total of 16 Division meetings were held in 2001.

APPENDIX 1

Basic programme		Inspection programme 2001 Loviisa power plant	Olkiluoto power plant
A	**Safety management**	X	
B	**Main functions**		
B1	Safety assessment and improvement	X	
B2	Operation		X
B3	Plant maintenance	X	X
C	**Inspections by functional unit and field of know-how**		
C1	Plant safety functions	X	X
C2	Electrical and I & C systems	X	X
C3	Mechanical engineering	X	X
C4	Construction engineering and structural engineering	X	X
C5	PSA and utilisation of fault statistics	X	X
C6	Information management	X	X
C7	Chemistry	X	X
C8	Nuclear waste	X	X
C9	Radiation protection	X	X
C10	Fire protection	X	X
C11	Emergency preparedness	X	X
C12	Physical protection	X	X
C13	Quality assurance	X	

APPENDIX 2 LICENCES AND APPROVALS IN ACCORDANCE WITH THE NUCLEAR ENERGY ACT

C214/227, 10 Jan. 2001, Teollisuuden Voima Oy
Importation of two fresh nuclear fuel rods from Germany. Max. 5 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom control stamp "P". In addition, obligations of the Finnish-Russian co-operation agreement on the peaceful uses of nuclear energy apply to the uranium. Valid until 31 December 2001.

C214/222, 11 Jan. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Germany. Max. 22 750 kg of uranium with a U-235 enrichment not exeeding 5%. Provided with the Euratom control stamp "P". In addition, obligations of the Finnish-Russian co-operation agreement on the peaceful uses of nuclear energy apply to 25 bundles. Valid until 31 December 2001.

C214/225, 17 Jan. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Spain. Max. 12 800 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom control stamp "P". In addition, obligations of the Finnish-Russian co-operation agreement on the peaceful uses of nuclear energy apply to 101 assemblies. Valid until 31 December 2001.

C214/226, 17 Jan. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Spain. Max 9 250 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom control stamp "N". In addition, 36 bundles are subject to obligations agreed upon in correspondence between Finnish and Chinese authorities. Valid until 31 December 2001.

A214/33, 5 April 2001, Fortum Power and Heat Oy
Importation of fresh nuclear fuel from Spain. Max. 120 tn of uranium with a U-235 enrichment not exceeding 4%. Provided with the Euratom control stamp "P". In addition, obligations of the Finnish-Russian co-operation agreement on the peaceful uses of nuclear energy apply to the uranium. Valid until 31 December 2005.

A214/33, 5 April 2001, Fortum Power and Heat Oy
Importation and exportation related transportation of the above-mentioned fresh nuclear fuel. Valid until 31 December 2005.

C214/228, 22 Nov. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Germany. Max. 22 750 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom control stamp "P". In addition, obligations of the Finnish-Russian co-operation agreement on the peaceful uses of nuclear energy apply to 118 bundles. Valid until 31 December 2002.

C214/229, 22 Nov. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Sweden. Max 7 500 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom control stamp "P". Valid until 31 December 2002.

C214/230, 22 Nov. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Sweden. Max 12 600 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom control stamp "S". Valid until 31 December 2002.

C214/231, 22 Nov. 2001, Teollisuuden Voima Oy
Importation of fresh nuclear fuel from Germany. Max 850 kg of uranium with a U-235 enrichment not exceeding 5%. In addition, four bundles are subject to obligations agreed upon in correspondence between Finnish and Chinese authorities. Valid until 31 December 2002.

C821/76, 19 Dec. 2001, Teollisuuden Voima Oy
The handing over to Ekokem Oy of a $9m^3$ batch of waste oil to be cleared from regulatory control. The oil is from Olkiluoto nuclear power plant and will be used for saw chain oil. Valid until 30 June 2002.

APPENDIX 3

Statements by STUK

A811/29, C811/21, 17 January 2001
A statement to the Ministry of Trade and Industry on the nuclear waste management programme for 2001 of Teollisuuden Voima Oy and Fortum Power and Heat Oy

Y211/7, 8 February 2001
A preliminary safety evaluation of the fifth reactor unit in planning to the Ministry of Trade and Industry

F214/9, 26 February 2001
A statement to the Ministry of Trade and Industry on VTT Chemical Technology's application for a licence for the multiple exportation and importation of fission chambers within the EU.

55/750/01, 28 May 2001
A statement on the IAEA draft guide "Safety Guide: Commissioning of Nuclear Power Plants (DS 291)"

60/750/01, 15 June 2001
A statement on the IAEA draft guide "Safety Guide: Recruitment, Qualification and Traning of Personnel for Nuclear Power Plants (DS 287)"

62/750/01, 26 June 2001
A statement on the IAEA draft guide "Safety Guide: External events in relation to NPP design (DS 301)"

74/750/01, 31 July 2001
A statement on the IAEA draft guide "Safety Guide: Fuel handling and storage systems in NPPs (DS 276)"

76/750/01, 20 September 2001
A statement on the IAEA draft guide "Safety Guide: Seismic Hazard Evaluation for Nuclear Power Plants (DS 302)"

78/750/01, 24 September 2001
A statement on the IAEA draft guide "Emergency Power systems at Nuclear Power Plants" (DS 303)"

78/750/01, 24 September 2001
A statement on the IAEA draft guide "Meteorological Events in Site Evaluation for Nucleaar Power Plants (DS 184)"

Y811/35, 27 September 2001
A statement to the Ministry of Trade and Industry on Posiva Oy's research, development and design programme and design programme for the period preceding the construction of a final disposal facility for spent fuel.

Y214/56, 17 October 2001
A statement to the Ministry of Trade and Industry on Fortum Nuclear Service Oy's licence application for software exportation to the IAEA and Egypt in accordance with the Nuclear Energy Act

82/750/01, 18 October 2001
A statement on the IAEA draft guide "Safety Guide: Seismic Design and Component Qualification for Nuclear Power Plants (DS 304)"

82/750/01, 18 October 2001
A statement on the IAEA draft guide "Safety Guide: Flood Hazard for Nuclear Power Plants on Coastal and River Sides (DS 280)"

81/750/01, 31 October 2001
A statement on the IAEA draft guide "Safety Guide: Periodic Safety Review of Nuclear Power Plants (DS 307)"

86/750/01, 20 November 2001
A statement on the IAEA draft guide "Safety Guide: Reactor Coolant and Associated Systems in Nuclear Power Plants (DS 282)"

C812/29, 14 November 2001
A statement to the Ministry of Trade and Industry on Teollisuuden Voima Oy's financial provision for nuclear waste management

A812/28, 14 November 2001
A statement to the Ministry of Trade and Industry on Fortum Power and Heat Oy's financial provision for nuclear waste management

A812/26, 14 November 2001
A statement to the Ministry of Trade and Industry on VTT's financial provision for nuclear waste management of the FiR 1 research reactor

89/750/01, 20 December 2001
A statement on the IAEA draft guide "Safety Guide: Reactor Core Design in NPPs (DS 283)"

P214-5/16, 20 December 2001
A statement to the Ministry of Trade and Industry on VTT Mineral Technology's licence application for the exportation to Estonia of ore concentrate (pyrochlore concentrate) containing uranium and thorium.

Decisions on NPP staff

P214-1/11, 5 February 2001
At the application of the Helsinki University Department of Chemistry's Laboratory of Radiochemistry, STUK approved Ms Sinikka Pinnoja as the deputy manager responsible for activities pertaining to nuclear materials at the laboratory.

F113/9, 12 February 2001
At the application of VTT Chemical Technology, STUK approved persons to act as FiR 1 research reactor foremen or operators until 31 December 2003.

P214-1/12, 29 November 2001
At the application of the Helsinki University Department of Chemistry's Laboratory of Radiochemistry, STUK approved Ms Kerttuli Helariutta as the manager responsible for activities pertaining to nuclear materials at the laboratory.

A113/108, 29 March 2001; A113/111, 21 May 2001; A113/112, 25 May 2001; A113/113, 3 July 2001; A113/114, 31 October 2001; A113/117, 18 December 2001; A113/118; 21 December 2001
At the application of Fortum Power and Heat Oy, STUK approved persons in the applicant's employ to act as shift managers or operators at the Loviisa plant units.

C113/173, 29 March 2002; C113/174, 10 May 2001; C113/175, 27 June 2001; C113/177, 27 June 2001; C113/179, 4 October 2001; C113/180, 24 October 2001; C113/181, 27 November 2001; C113/182, 19 December 2001
At the application of Teollisuuden Voima Oy, STUK approved persons in the applicant's employ to act as shift managers or operators at the Olkiluoto plant units.

APPENDIX 4 Safety research projects completed in 2001

Nuclear power plants

FINNUS—the Finnish Research Programme on NPP Safety

Ageing and failure mechanisms of modern I&C equipment; VTT Automation

Comparison of the FRAPTRAN and SCANAIR codes; VTT Energy

Thermal stratification in NPP pipes; VTT Energy

A method for identifying, modelling and propabilistically assessing human commission errors, a continuation project; VTT Automation

Development of structural analysis methods for fracture mechanisms; VTT Manufacturing Technology

Safety assessment of programmable automation, a continuation project; VTT Automation

Modelling of oxide film behaviour and their role in activity buildup and in different corrosion phenomena at NPPs, a continuation project; Manufacturing Technology

Reliability assessment and licensing methodology of passive systems, a continuation project; VTT Automation

Development of fuel analysis capabilities; validation of FRAPTRAN-code; VTT Energy

Fuel cladding corrosion mechanisms and their modelling, a continuation project; VTT Manufacturing Technology

Effect of smoke and heat on electronic equipment, modelling of fires for risk analysis, active fire protection equipment; VTT Building Technology

The factors influencing the containment integrity test results; VTT Energy

Development of methods for small specimen toughness characterisation of irradiated materials; VTT Manufacturing

In-service inspections and condition monitoring: Development of qualification of NDT methods; VTT Manufacturing

In-service inspections and condition monitoring: Development of ultrasonic simulation and modelling capabilities; VTT Manufacturing

Developing working practises and culture in daily operations; VTT Automation

TRAB-3D code; code verification, a continuation project; VTT Energy

Criticality safety of fuel transportation container; VTT Energy

The application of new reactor physics models in criticality safety calculations; VTT Energy

Environmentally assisted cracking of NPP materials, a continuation project; VTT Manufacturing Technology

Research supporting regulation

The distribution of sea water level; Finnish Institute of Marine Research

The release and behavior of ruthenium in severe reactor accidents; VTT Chemical Technology

The prescriptivity and consistency of nuclear safety regulation; VTT Automation

SAFETY RESEARCH PROJECTS COMPLETED IN 2001 **APPENDIX 4**

The organisms of sea water effecting the nuclear safety; Finnish Institute of Marine Research

The selection of NPP siting and environmental risks, VTT Energy

Studies in concrete technology for the construction, inspection and repairing of NPP structures, a continuation project; VTT Building Technology

The requirements of NPP containment coating; VTT Building Technology

Nuclear waste management

Research supporting regulation

The computational modelling of the mechanical and physical processes of a nuclear waste repository. HUT, Laboratory of Theoretical and Applied Mechanics.

Groundwater flow paths. Fracture characterization of a road cut. Geological Survey of Finland.

Interpretation and characterisation of fracture zones at Olkiluoto site by focussed modelling. Geological Survey of Finland.

Uranium series study. University of Helsinki, Laboratory of Radiochemistry.

Matrix diffusion research: Indications of radionuclide transport in a postglacial weathering profile (natural analogue investigation). University of Helsinki, Laboratory of Radiochemistry.

Matrix diffusion cluster; Treatment of geosphere retention processes in safety assessments: measurement and modelling of matrix diffusion. Université de Poitiers/HYDRASA.

Interpretation of disturbance structures in Holocene submarine sediments in the Olkiluoto area, the Gulf of Bothnia, Baltic Sea, using a high resolution echo-sounding profiles. Geological Survey of Finland.

The Definition of Irradiated Fuel (for Safeguards).

Redox buffering and uranium retardation in nuclear waste repository. University of Catalonia.

Treatment of geosphere retention processes in safety assessments: measurement and modeling of matrixdiffusion ("Matrix Diffusion Cluster"). University of Helsinki, Laboratory of Radiochemistry.

Expert assessment

Review of Posiva's R&D programme; University of Aberdeen (Prof. F.P. Glasser).

Contribution to international research projects

Electrochemical and electric properties of surface films on copper in simulated groundwater. VTT Manufacturing Technology.

DECOVALEX III—Bench Mark Test 2 simulations. Work done in 2000. University of Uppsala

IAEA coordinated research project (CRP). Natural geochemical concentrations and fluxes on the Baltic Shield in Finland as indicators of nuclear waste repository safety. Work done in 2001. Geological Survey of Finland.

IAEA coordinated research project (CRP). Natural geochemical concentrations and fluxes on the Baltic Shield in Finland as indicators of nuclear waste repository safety; The use of selected safety indicators (concentrations, fluxes) in the assessment of radioactive waste disposal. University of St. Petersburg.

IAEA coordinated research project (CRP). Natural geochemical concentrations and fluxes on the Baltic Shield in Finland as indicators of nuclear waste repository safety; Dispersion haloes and fluxes of chemical elements in the cryolithozone (permafrost or periglacial regions). University of St. Petersburg.

DECOVALEX III—Thermal studies for FEBEX experiment. Work done in 2001. HUT, Laboratory of Theoretical and Applied Mechanics.

DECOVALEX III—BMT3 permafrost modelling. Work done in 2001. HUT, Laboratory of Theoretical and Applied Mechanics.

DECOVALEX III—BMT2 rock mechanical simulations in 2001. HUT, Laboratory of Rock Engineering.

APPENDIX 5

ANNUAL MAINTENANCE OUTAGES

Loviisa 1 annual maintenance

The Loviisa 1 refuelling and maintenance outage started on 11 August 2001 and ended on 31 August 2001. The plant unit was off the grid for about 20 days. The outage was four days longer than planned, which was due to an investigation into the causes of vibrations in the primary coolant pumps and the replacement of one pump. The pump vibrations are described in more detail in Appendix 6. In addition to refuelling, outage work included maintenance and modification of components, structures and systems. Safety-significant modifications are described in Appendix 7.

Both Loviisa plant units introduced new procedures for main control room operations during annual maintenance to provide for well-defined and undisturbed circumstances for operators and other persons working in the control room. In addition, a new plant safety instruction was introduced to systematically assure a sufficient plant safety systems availability during annual maintenance.

During the outage radiation dose rates in some primary circuit locations were 25–40% above normal level. This may partly have been due to a change in the water chemistry of the primary circuit. A process coupling different from the one usually used for shutdown prior to an annual maintenance outage was employed during this shutdown because a valve had failed. The higher-than-normal radiation dose rates had no signficant bearing on occupational dose rates, however.

The outage-induced collective radiation dose for Loviisa 1 was 0.70 manSv. According to guidelines set by STUK, the threshold value for the collective dose for a Loviisa plant unit is 1.22 manSv averaged over two successive years. The annual collective radiation dose is mostly incurred in outage work. The highest individual dose during the Loviisa 1 annual maintenance of 2001 was 11.5 mSv. The Radiation Decree prescribes that the annual effective dose to a radiation worker may not exceed 50 mSv. About 900 persons involved in the Loviisa 1 annual maintenance outage were subject to personnel monitoring. Fig. A5.1 of this Appendix gives the collective occupational doses incurred in maintenance work over the past years.

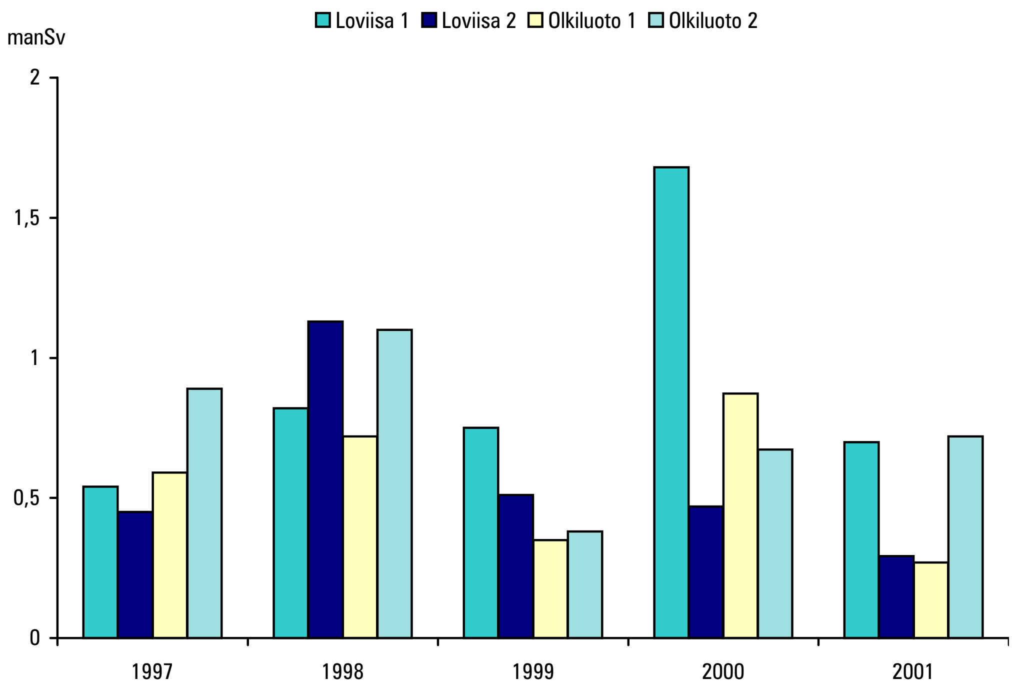

Figure A5.1. *Collective occupational doses incurred during the annual maintenance of Loviisa and Olkiluoto plant units..*

APPENDIX 5

Loviisa 2 annual maintenance

Loviisa 2 was shut down for refuelling and maintenance from 1 to 23 September 2001. The plant unit's start-up was postponed by about six days from the planned date mainly because of an investigation into the causes of primary coolant pump vibrations. The unit was off the grid for about 22 days. In addition to refuelling, outage work included maintenance and modification of components, structures and systems the most important of which are described in Appendix 7.

A leak of mildly radioactive water occurred within the plant unit during the annual maintenance. The event is described in Appendix 6.

The collective radiation dose incurred from outage work was 0.29 manSv. The highest individual radiation dose was 4.4 mSv. About 900 persons involved in the outage were subject to personnel monitoring. Fig. A5.1 of this Appendix gives the collective occupational doses accumulated in maintenance work over the past years.

In connection with the regulatory control of mechanical components and structures it was noted that the Loviisa plant's inspection unit "Inspection Body Loviisa NPP" had proceeded incorrectly during one inspection. The structural inspection of a primary coolant pump sealing water system heat exchanger modification was carried out by an inspector who lacked the required STUK-granted inspection authorisation. The inspection protocol was drawn up by an "Inspection Body Loviisa NPP" inspector who had the required authorisation. The licencee provided STUK with a report on the incorrect procedure and the measures that followed. STUK assessed the measures and considered them appropriate and sufficient.

Olkiluoto 1 annual maintenance

Olkiluoto 1 was shut down for refuelling on 21 - 29 May 2001. The plant unit was off the grid for about eight days. An erroneous neutron flux control system signal actuated the reactor scram function in the plant unit shutdown phase. The control rods had already been inserted into the reactor and, thus, no actual scram occurred. In addition to Teollisuuden Voima Oy's own personnel, the number of external workers contributing to the annual maintenance outage was 640 at its most. In addition to refuelling, outage work included maintenance and modification of some components, structures and systems. Safety-significant plant modifications are described in Appendix 7.

Significant maintenance items included the replacement, inspection and testing of valve actuators needed in an accident situation. In the autumn 2000, damage and cracks had been observed in the bakelite gears of the reactor core emergency cooling system actuators, which might have prevented valve operation according to design. The event is described in Appendix 6.

During the outage, the licencee inspected those emergency cooling system pipe sections inside the reactor pressure vessel in which cracking induced by thermal fatigue had been observed in 1998 and 1999 (STUK-B-YTO 184, 1999 and STUK-B-196, 1999). The cracks were repaired and the pipes fitted with thermal shields to prevent further cracking. In the inspections now conducted, the slight movement of one thermal shield was detected. The shield had moved before and had been retightened during the 2000 annual maintenance. Since the repair method used in 2000 was insufficient and the work requires divers—and increases worker radiation exposure—the licencee is working to come up with an improved solution by the 2002 annual maintenance for keeping the thermal shield in place. STUK approved the postponement of the shield's re-tightening until the 2002 annual maintenance outage because it's total shifting during plant unit operation is quite unlikely. The shield's observed minor dislocation does not essentially increase the risk of thermal fatigue in the emergency coolant pipes.

The outage-induced collective radiation dose was 0.27 manSv. According to guidelines set by STUK, the threshold value for the collective dose for an Olkiluoto plant unit is 2.10 manSv. The annual collective radiation dose is mostly incurred in outage work. The highest individual dose during the Olkiluoto 1 annual maintenance of 2001 was 8.8 mSv. The highest individual radiation dose incurred during the Olkiluoto 1 and 2 annual maintenance outages was 11.5 mSv. Fig. A5.1 of this Appendix gives the collective occupational doses accumulated in maintenance work over the past years.

Olkiluoto 2 annual maintenance

Olkiluoto 2 underwent annual maintenance from 6 to 21 May 2001. It was off the grid for about 15 days. In addition to Teollisuuden Voima Oy's own personnel, the number of external workers contributing to the annual maintencance outage was 800 at its most. In addition to refuelling, outage work included maintenance and modification of components, structures and systems. Safety-significant plant modifications are described in Appendix 7.

The actuators of valves needed in accidents were replaced, inspected and tested at Olkiluoto 2 as well. The work is described in more detail in Appendix 6.

Important outage work included the repair of a few square metres of sea water tunnel floor concrete structure in which cracking had occurred owing to reinforcement steel corrosion. The corrosion was caused by sea water salt and a mistake made during the construction phase since the concrete layer protecting the steel was very thin originally. The corrosion protection system for reinforcement steels, installed in the sea water tunnels during annual maintenance, is described in Appendix 7.

The collective radiation dose incurred in work during the outage was 0.72 manSv. The highest individual radiation dose during the Olkiluoto 2 annual maintenance outage of 2001 was 7.8 mSv. Fig. A5.1 of this Appendix gives the collective occupational doses accumulated in maintenance work at the Olkiluoto plant units over the past years.

APPENDIX 6

Loviisa power plant

Ventilation system of Loviisa 1 diesel generator room partially inoperable

On 23 October 2000 a 2-weekly diesel generator functional test revealed that the fans of one thermostatically operated air cooling unit of the Loviisa 1 diesel generator room failed to start. An erroneous coupling of the thermostat was repaired in three days in compliance with the Technical Specifications. In addition, a work order was submitted to inspect the control function of air cooling units of three other diesel generator rooms. In January 2001 it was found out that inspections in accordance with the work order had not been made. They were made in January/February and revealed no operationally significant defects.

The fresh air fans of the diesel generator room ventilation system and three air-cooling units are normally on standby. They are set into action by thermostats when the room temperature rises. During a fire or the inoperability of the fresh air fans, service water cooled air-cooling units are used.

Due to the erroneous thermostat coupling, the fans of the air-cooling unit that would start at highest temperature would not have automatically started; however, they would have been available by manual control. Two other air cooling units and the fresh air fans would have operated according to design. The cause of the erroneous coupling has not been identified. Although nothing out of the ordinary had been observed during earlier testing, the fans could have been inoperable for a long time since their operation has not been reliably verified during testing. The event is of minor safety significance because, in case of the loss of the external grid, three other diesel generators would have supplied reserve power if the diesel in operation had been made inoperable by high diesel generator room temperature. The event was classified INES Level 0.

The testing instructions of the air cooling units were made more specific by the utility. In the 2001 annual maintenance outage, one thermostat regulating the temperature of one diesel generator room was replaced by a newer type of thermostat and the coupling of the control circuit of another diesel generator was changed to correspond to the starting order of the fans.

Loviisa 1 reactor scram

A power supply malfunction occurred at Loviisa 1 on 9 February 2001 when disconnected cables in the instrumentation room of the control building were being removed from service. In an I & C system modification in 1986, four cables had remained connected to the plant protection system cubicles by mistake and were thus partly live. The cutting of a live cable was followed by a short circuit that closed nine isolation valves of the containment building among others. When the operator noticed the situation he manually scrammed the reactor. The plant unit was operating at full power at the time of the event.

The power supply, which was cut off by the short circuit, was resumed in about nine minutes and the closed isolation valves were opened.

When the isolation valve of the primary circuit make-up system return line closed, the circuit's safety valve to the steam generator room opened. After the scram the operator tripped the primary coolant pumps and closed some control valves in order to close the open safety valve. When an isolation valve in the control rod cooling system was closed the system's safety valve in the steam generator room opened. The valve's closing impaired control rod drive cooling but the temperature increase was insignificant because the cooling system was out of operation for eight minutes only. The other closed isolation valves required no immediate action.

Ca. 1.2 m^3 of primary circuit water entered the floor drains of the steam generator room via the safety valves. The water was channelled to a water treatment system tank.

Cable ends were unwound and isolated and the operation of the containment building isolation valves tested. The plant unit was re-synchronised with the national grid on 10 February 2001. The steam generator room was checked prior to the plant unit's start-up. The event was classified INES Level 0. As a further measure the utility improved the cable removal procedures.

Significant operational events

APPENDIX 6

Control rods were inserted deeper into the Loviisa 1 reactor core than allowed by the Technical Specifications

During a Loviisa 1 reactor start-up on 10 February 2001, after a reactor scram on 9 February 2001, one control rod group was inserted, for ca. four hours, deeper into the reactor core than allowed by the Technical Specifications. Consequently, the fuel operating limits were slightly exceeded.

The 37 control rods in the reactor of the Loviisa plant units are divided into six groups, only one of which is inserted into the reactor during normal operation to control reactor power. The maximum limit on the insertion of the rod group into the reactor core is given in the Technical Specifications. It ensures the maintenance of fuel operating limits and a sufficient shutdown margin.

The reactor had been in a shutdown state for about 14 hours prior to the post-scram start-up. Due to certain reactor physical phenomena, the reactor's operational state in that case promotes a slow power increase. In a case such as this the inserted control rod group tends to compensate for the power increase by inserting itself deeper into the reactor core, unless the power increase is prevented by the injection of a sufficient amount of neutron-absorbing boric-acid water into the reactor. Boric-acid water was injected into the reactor on several occasions during the start-up, but far too carefully, whereupon the control rods moved too deep into the reactor.

The event was caused by the fact that, owing to the infrequency of the situation, the need to inject into the reactor a large amount of boric-acid water as well as the effect of the power increase on the reactor status at the time of the event were not sufficiently well understood by the operating shift. The previous Loviisa 1 post-scram start-up had been in 1994. The plant unit has instructions for such situations but the night shift on duty at the time of the start-up failed to properly read them to understand what procedures should have been taken, which was due to other pressures related to the reactor start-up.

The fuel operating limits were so slightly exceeded that the event had no safety significance. It was assigned INES Level 0.

After the event the utility intensified operator training and improved the control room display and alarm systems used by operators in the control room.

Primary coolant pump vibrations and cracks in the supporting structures of the pumps' vanes at Loviisa 1 and 2

During the servicing of primary coolant pumps in the Loviisa 1 annual maintenance outage cracks were observed in the supporting structure of one pump's guide vanes. This pump had been added to the maintenance programme because, during a modification, water had entered its surrounding structures. It was suspected, however, that vibrations during plant start-up and shutdown had caused the cracks because such vibrations had damaged supporting structures previously. After the previous outage vibrations had been observed in another primary coolant pump as well, which was included in the maintenance programme. Similarly, a pump outside the annual maintenance programme was inspected during the Loviisa 2 annual maintenance due to vibrations observed in it. Corresponding cracks were detected in both pumps. Damaged components were replaced by spare parts and vibration monitoring was increased.

Despite the improvements made, vibrations were observed even during post-outage start-ups. At Loviisa 1 vibrations occurred in two other primary coolant pumps and they ended before the plant unit was operating at full power. At Loviisa 2 a vibrating pump had to be replaced for which procedure the plant unit had to be cooled again to a shutdown state. No vibrations were observed during the new start-up.

Both Loviisa plant units have six primary coolant pumps. The problem of cracked supporting structures was first observed in 1995. The breaking of a structure at Loviisa 2 brought about a primary coolant pump malfunction and the shutdown of the plant unit for repairs (STUK-B-YTO 149, 1996). In consequence of the event, the flow direction of the loop in question had reversed, and loosened components had been transported away from the reactor towards the steam generator. In the 1997 annual maintenance outage, corresponding cracks were detected in one Loviisa 1 primary coolant pump (STUK-B-YTO 169, 1998).

The cause of the damage and its elimination are still under examination. During the 1995 annual maintenance outage metallurgical studies were conducted demonstrating that crack growth and the final fracturing of the structure were due to vibration fatigue. A new study made during the 2001 annual maintenance outage confirmed this observation despite the fact that, since the year 1995, all supporting structures had been replaced with ones having better fatigue resistance. Even more durable structures are under design. In addition, stresses arising from temperature differences and the effects of the reactor coolant circuit's hydraulic behaviour are being scrutinised.

A leak of mildly radioactive water during Loviisa 2 annual maintenance

During the annual maintenance outage, on 8 September 2001, a make-up system water tank overflowed and 4.7 m^3 of water escaped to the emergency coolant pump rooms. At the time of the event, mildly radioactive water from the reactor pool was being pumped via the pool water purification plant to the tank that was quite full already. The 1000 m^3 capacity emergency make-up tank is used to store up water from the primary circuit, or systems connecting to it, during outages. In emergencies the boric-acid water contained in the tank is used to cool down the reactor.

The water flow routes and the emergency coolant pump rooms were decontaminated and the motors of pumps located in the rooms were checked. No significant soak damage was observed in the inspection but water had splashed on some motors. To dry them up, the pumps were run for about an hour.

The spilled water's activity was ca. 4000 Bq/l, i.e. it's total activity was ca. 18.8 MBq. The event and the decontamination after it did not cause significant radiation doses to the personnel.

The overflow occurred because it was not ensured by calculations that there would be enough room in the tank for the amount of water to be transferred and because the tank's water level was not monitored carefully enough. In addition, the operators did not immediately react to an alarm signal indicating a high water level in the tank. To prevent recurrence, a condition will be added to the procedure instructions requiring that the accommodation of the amount of water to be transferred be checked prior to the transfer and, further, that the alarm signal indicating a high water level in the tank be given a high priority.

The event was rated INES Level 0.

A crack in the shroud tube of a control rod drive of the Loviisa 2 reactor

During a once–a–month checking round at Loviisa 2, on 18 December 2001, crystallised boron was found in structures above the reactor pressure vessel. The boron originated in primary circuit water and was an indication of a primary circuit water leak. Crystallised boron had accumulated on the surface of a temperature detector pocket welded on a control rod drive shroud. The control rod shrouds, attached to the reactor pressure vessel lid by bolted joints, are part of the primary circuit's pressure-retaining boundary.

In ultrasonic inspections the next day, a crack penetrating the control rod shroud wall was found from beneath the detector pocket. Through this crack, boron containing primary circuit water had accessed the detector pocket, ending up on the structure's surface.

The plant unit was placed in cold shutdown on 19 December 2001 for repairs. The detector pocket was removed and the surface of the control rod shroud was polished prior to surface inspection. A crack with multiple branches was observed under the pocket. In addition, an individual surface crack was found below the pocket area. This crack was removed by grinding. The through-wall crack area was temporarily fixed by welding a pressure-retaining band structure on it.

During the outage, the wall area of 25 easily accessible detector pockets out of a total of 37 shrouds above the reactor lid were also inspected by ultrasound. The signs of a minor surface defect were found in one of them, which required no measures. After repairs and inspections were completed, the plant unit resumed power generation on 22 December 2001.

The event was classified INES Level 0.
The temporarily fixed shroud tube will be replaced by a spare part in a 2002 maintenance outage. The tube to be removed will be examined in order to determine what caused the cracking. Both plant units will also enhance monitoring of the points in question.

A position switch of a containment underpressure valve was inoperative at Loviisa 1
A periodic test at Loviisa 1 on 14 December 2001 revealed a defective position switch in a containment underpressure valve. The switch relates to severe accident management. The Technical Specifications require that it must be in working order during plant unit operation. Relevant Technical Specifications requirements came into effect during the plant unit's start-up from annual maintenance in August 2001.

A containment underpressure system prevents buckling during events involving a significant underpressure within the containment. The system's underpressure valves automatically open, when necessary. Their position switches transmit data on valve positions to the control room. Data transmission has been assured by means of additional switches operating even in severe accident conditions. The position switches do not control the operation of systems or components. The valves' switches, which transmit regular position data, were in operating order and the control room was thus aware of the valve's condition all the time.

The installation of additional switches had been part of an ongoing long-term project to improve severe accident management. The Technical Specifications were ignored due to a break in the flow of information between the line organisation and the project organisation carrying out the work.

The event was of minor safety significance and its INES classification is Level 0.

Owing to the event, the utility plans to improve procedures relating to the management of modifications onsite. The flow of information between the project and line organisations will be enhanced, among others, and training given to the facility personnel on the bases and purpose of the Technical Specifications will be increased.

Olkiluoto power plant

Reliability of reactor core emergency cooling at Olkiluoto plant units diminished due to valve actuator malfunctions
Defects and cracks had been observed in the bakelite gears of the actuators of valves controlling reactor core cooling in accidents. Due to them, the valves might not have operated if needed. The event was classified INES Level 1. The gears were replaced with brass gears.

The reactor core cooling system comprises four identical sub-systems for injecting emergency coolant into the reactor at low pressure to compensate for a primary circuit leak. In such a situation the reactor water level is controlled by opening and closing sub-system valves that are, at the same time, containment building external isolation valves. One operating subsystem is sufficient to ensure successful emergency cooling. In most accidents the reactor core cooling system may be compensated for by the auxiliary feed water system.

The valve actuator problem first appeared on 14 August 2000 when a coolant-regulating valve failed to open in a periodic test at Olkiluoto 1: some teeth in the bakelite gear of its valve actuator had broken. A corresponding actuator from the storage was installed in its place. A corresponding valve in another sub-system of the reactor core cooling system failed to close in a periodic test on 11 December 2000. Teeth had broken off the bakelite gear of the valve actuator as well. Since there were no new bakelite gears or replacement actuators in storage, the damaged gear was replaced by a brass gear made according to drawings.

Due to recurring failures the licencee decided to continue the replacement of bakelite gears with

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brass ones made onsite. The only actuator in store, removed from Olkiluoto 1 in August, was fitted with a brass gear on 3 January 2001. It was then installed for use in Olkiluoto 1. The bakelite gear of the actuator, removed from the plant unit, was inspected by penetrant testing that revealed four crack initiations. In addition, a gear removed from the plant unit in December was checked by the same method. In addition to the broken teeth, cracks were identified in three teeth.

Based on the inspection results, the schedule for substituting brass gears for the old ones at Olkiluoto 2 was speeded up and the first replacement was made on 11 January 2001. The gear detached from the actuator had several cracks, one reaching the middle of a tooth. The tooth in question was tested for durability in a test bench the same day. Nothing out of the ordinary was detected in the functional test. In an inspection after the test, however, the worst cracked tooth was found to have broken.

After the inspections and replacements had been completed there was reason to suspect the operability of the external isolation valves in three Olkiluoto 2 and two Olkiluoto 1 sub-systems. At Olkiluoto 2 this meant that, if the reliable operation of the valves could not be ensured, the operation of the plant unit would have to be stopped within 24 hours to comply with the Technical Specifications. According to the Technical Specifications, Olkiluoto 1, where the operability of only two sub-system valves had been questioned, had three days to repair the failures prior to having to shut down the plant unit. At Olkiluoto 2 the bakelite gears of the actuators were replaced with brass ones during the night of January 11 to 12, 2001 and at Olkiluoto 1 in the afternoon of January 12, 2001.

Material technological analyses of what had caused the failure of the bakelite gears were made. The cracking was probably due to fatigue. The analyses yielded no proof of material ageing. Corresponding faults had been observed at facilities abroad in the 1980's and 1990's and one case at Olkiluoto facility as well. However, Olkiluoto had taken no measures due to these individual cases.

Owing to the event the licencee further specified the procedures and instructions for valve actuators. In the 2001 annual maintenance outage at Olkiluoto 1 the bakelite gear of one valve actuator was replaced with a new bakelite gear and the gears of two actuators were checked. In an Olkiluoto 2 outage the gears of four actuators were replaced with new bakelite gears and the removed gears were checked. They were in good condition and had no cracks. In addition, one actuator having a new bakelite gear underwent functional testing in a test bench to establish its durability. Post-testing inspections found the gear was in good condition. The follow-up and replacement of valve actuators containing bakelite gears and of their gears will continue in the coming years.

Olkiluoto 2 reactor scram

A reactor scram in consequence of a turbine-related operational malfunction occurred at Olkiluoto 2 on 21 March 2001. Safety systems operated as designed.

The malfunction was caused by a failure of the level measurement of a drainage tank on the turbine side. The failed measurement function indicated, without cause, too low a level in the tank, leading to a bypass of one high pressure preheater line of the reactor feed water system and a partial reactor scram. In the partial scram, some control rods were hydraulically inserted into the reactor core, decreasing the reactor power to ca. 20% level. Owing to the bypass, the temperature of water injected into the reactor dropped and, consequently, the reactor power began to rise in a way typical of a BWR. Power exceeded 56 per cent in two out of four measurement points assessing power. A reactor scram followed and all control rods were hydraulically inserted into the reactor core and reactor power dropped to zero. The event resulted in a reactor scram because the partial scram function was not sufficient in this situation to maintain reactor power below the 56 per cent scram threshold.

The failed level measurement device was replaced and the plant unit was re-synchronised with the national grid on 22 March 2001. The event was classified INES Level 0.

The licencee carried out the necessary measures to enhance the scram function at both plant units during annual maintenance outages.

Situations in non-compliance with the Technical Specifications at Olkiluoto 2 during a modification of the reactor control rod manoeuvring and position indication system

Two situations occurred during the Olkiluoto 2 annual maintenance outage during which the plant unit was in non-compliance with the Technical Specifications. In one of them, an automatic function preventing the withdrawal of control rods had been bypassed, i.e. removed from operational readiness, and in the other, data on control rod positions in the reactor, which should have been available in the control room, was lacking. The events occurred during a modification of the reactor's rod control and rod position indication system. The modifications are described in Appendix 7.

A bypass of the automated function preventing control rod withdrawal occurred during refuelling when functional tests of the revised system were carried out simultaneously with reactor core internal fuel transfers. The licencee on 13 May 2001 applied for STUK's permission to bypass the screw shutdown function during functional testing, since the tests could not otherwise have been done. Automated screw shutdown assures the hydraulic scram function, which drives control rods into the reactor core by means of electric motors during a scram situation, if necessary. The Technical Specifications require that the screw shutdown function be tripped during core internal fuel transfers. In the morning of 14 May 2001 STUK's inspectors noticed that during the functional tests of the reactor control rod manoeuvring and position indication system, which had been conducted so far, it had been necessary to also bypass automation preventing reactor control rod withdrawal. The Technical Specifications require that it must be in full operational readiness during refuelling, among others. The automation is intended to prevent control rod withdrawal that could lead to unintentional criticality.

The event was attributed to an erroneous interpretation of the Technical Specifications. It was assumed to be partly due to an event two days previously on 11 May 2001 when, after an electrical separation, the control room had lost data on all rod positions in the reactor. The Technical Specifications were interpreted in such a way onsite that functional testing of the rod control and rod position indication system could be continued in the situation in question. It was noted later that rod position data should have been restored and STUK's permission asked to continue work. The requirements of the Technical Specifications were thus deviated from also during this event.

The bypassing of automation preventing control rod withdrawal or the lacking control rod position data had no safety significance in practice in the situation in question because all control rods were fully inserted into the core and, to prevent their manoeuvring, the fuses of their drives had been removed and their electric breakers opened. STUK on 14 May 2001 approved, on the basis of the utility's application, the bypassing of automation preventing rod withdrawal for the rest of the functional testing of the the rod control and rod position indication system.

The events were assigned Level 0 on the INES.

Improvements identified as necessary by event analysis are due for implementation prior to the realisation of corresponding installation work at Olkiluoto 1 in 2002.

Inoperability of two reactor feed water conductivity measurements at Olkiluoto 2

The operators of Olkiluoto 2 on 23 May 2001 observed, based on process computer trend monitoring, that two reactor feed water conductivity measurements displayed erroneous values. Troubleshooting indicated that conductivity transmitters did not send signals, which rendered the measurements inoperable. Disconnected electrical connectors were connected and the measurements were restored to operation the same day. They were inoperable for about three days.

The conductivity of water injected into the reactor is continuously measured at four measurement points. High conductivity indicates a service water leak in the turbine condenser. If the conductivity of feed water exceeds a limit value, the transmitters give out a signal closing the valves of the feed water lines, preventing injection of water into the reactor. The reactor pressure vessel, its internals and instrumentation are thus protected against corrosive chlorides. The protective signal activates when two measurement points indicate an excessive value. According to the Technical Specifications, the four measurement functions must be operational during plant unit operation. In this situation the operative state of the signal depended on two conductivity measurements.

Electrical connectors had been detached since an annual maintenance outage that ended on 21 May 2001. In the outage the conductivity measurements were calibrated prior to which their electrical connectors had to be disconnected. Afterwards the connectors were not restored to operation by mistake. Their disconnected state had been entered in an unofficial checklist but the shortcoming went unnoticed until an inspection that was conducted before the plant unit's start-up.

Because of the event, procedures will be revised to prevent recurrence. Connector inspections, among others, will be included as an entry in the instructions for relay cubicle inspections; and post-calibration operation of the conductivity measurements will be assured using a computer trend display.

The event was classified INES Level 0.

APPENDIX 7

Loviisa power plant

The main circulation pump sealing water system was improved
In the 2001 annual maintenance outages of both Loviisa plant units improvements were made to the sealing water system of the main circulation pumps to assure system operation in transients and accidents. The same improvements at Loviisa 2 were due in the 2000 refuelling outage already but were postponed because of a delay in the handling of documents relating to the modification (STUK-B-YTO 208, 2001).

The mechanical seals of the main circulation pumps require continuous cooling and could sustain damage if left without cooling for several hours, in consequence of which a minor leak from the primary circuit could occur. The importance of sealing water supply and the need to improve it has been identified on the basis of the results of probabilistic safety analyses, among others.

During normal operation the seals are cooled by primary circuit water that, for its part, is cooled by intermediate cooling system water. The intermediate cooling system is cooled by the service water system. The improvements make it possible to cool the seals with boron system water. Boron system water need not be separately cooled since it is cold enough as such. After the modification, the supply of sealing water automatically reverses to take place from the boron system in case sealing water temperature exceeds 50°C. At the same time, normal sealing water supply from the primary circuit purification system is automatically prevented to isolate a possible sealing water system leak. The mechanical seals of the main circulation pumps withstand temperatures of 70–80°C. The improvements also include modifications to the protection and control systems and new temperature measurements.

The improvements ensure the operation of the seals not only in case normal sealing water system cooling is lost but also in case of system pipe breaks. The isolation of leaks from the sealing water system will be further assured in the 2002 annual maintenance.

Reduction of risks from containment external leaks
Modifications have been made at both Loviisa plant units to reduce the risk of leaks from the primary circuit to outside the containment through various systems. The need for modifications has surfaced during the updating of the plant units' probabilistic safety analysis. In connection with the updating, the licencee assesses the routes and consequences of the leaks, among others. The most important risk factors include, among others, leaking valves in the drainage and venting systems relating to the reactor cooling system and also elevated temperatures and moisture contents caused by steam releases in transmitter rooms located in the ground floor of the reactor building. Temperature increases and moisture could bring about malfunctions in instrumentation.

During the 2001 annual maintenance outages, an isolation valve was added to the reactor building drainage system and the connection between the reactor building venting system and the discharge line was removed. The modification reduced the likelihood of leaks external to the containment through the venting and drainage systems. In addition, the utility made more specific plant instructions for the management of minor leaks from the primary circuit as regards the detection and isolation of leaks external to the containment building.

To reduce the risk of leaks external to the containment, the plant units will also make other modifications whose implementation schedule STUK has approved.

Operational parameters of emergency cooling system water tanks were changed
The operational parameters of the hydroaccumulators of the reactor emergency cooling systems were changed at both plant units in the 2001 annual maintenance outages. The change in operational parameters meant an enlargement in the water volume of the pressurised water tanks and a reduction in their original operating pressures. The modifications improve reactor core cooling in the event of primary circuit leaks. Consequently, a

12.5% increase in maximum fuel burn-up became possible (see subsection 4.1.4).

The modification is part of a more extensive emergency cooling system upgrading, approved in 1999. During those improvements, the cooling function will be optimised and the low pressure emergency coolant pumps replaced. Some of the pump replacements were made in 2000.

Modernisation of the fire detection system

Fire detection system replacement was completed at Loviisa power plant in autumn 2001. The system was replaced because it no longer met today's requirements for operation and reliability. In addition, obtaining spare parts for the system had become difficult.

The new fire detection system was constructed parallel with the operating system, which was removed from service after the new system was completed. The new system has sensitive, addressable fire detectors providing early detection and making possible the identification of fire location to a single detector. All this advances the starting of automatic extinguisher systems and the initiation of operative fire fighting measures. In addition, proper detectors for each room are selected to minimise false alarms. Data from the fire detection centre is transferred into a graphics system functioning as an alarm-receiving user interface. By the interface, the fire detection system can be controlled and system event data aggregated.

Renewal of hydrogen units

The location of hydrogen units at Loviisa plant was changed and the units were replaced. They were moved from the outer wall of the turbine buildings to about five meters' distance from the buildings.

The generators of Loviisa plant are cooled by hydrogen because it has good heat transfer properties. A constant volume of hydrogen circulates in the generators and more is taken from the hydrogen units, if necessary. A hydrogen leak at the Loviisa 2 hydrogen unit in 1999 (STUK-B-YTO 202, 2000) initiated the renewal of the units. After the event the utility assessed the technical realisation of the units, their operational safety and the correctness of maintenance measures. In the old units, also the signs of ageing were observed.

Both hydrogen units comprise eight hydrogen bottles. The bottles were placed in bunkers specifically built for them, made of reinforced concrete and open on one side. The walls of the bunkers would protect the adjacent buildings from the pressure that would develop in a potential hydrogen explosion. In addition, the developing pressure would be channelled by the open wall of the bunkers to a direction where there are no structures or buildings that could sustain damage.

Renewal of the electric motors of pumps of the Loviisa 2 service water system

Power analyses relating to the electric motors of the pumps of the plant's service water system performed in connection with the Loviisa 2 modernisation project indicated that the operating capability of the motors in undervoltage situations had to be increased. The main function of the service water system is to assure, under all plant unit operational conditions, the reliable and sufficient supply of cooling water to the heat exchangers of several systems important to safety, and to redirect warm water from the heat exchangers back to the sea.

On the basis of the results of the analyses the licencee decided to modernise all motors of the service water systems and their reserve motor. The motors are original components. Modernisation was carried out by rewinding them. The rewinding was begun in spring 2001 and was continued such that the last rewound motor was taken into service in the Loviisa 2 annual maintenance outage. The rewinding of the reserve motor was completed towards the end of the year.

The bearing of the first rewound motor was damaged in August, after having been in operation for about five months. The damage was attributed to lack of lubricant. The motor's bearing and shaft were changed and the motor was serviced. No corresponding problems appeared in other motors.

The power requirement and capacity of Loviisa 1's corresponding pump motors in undervoltage situations has also been examined. The results indicate that the capacity of the pump motors in service at Loviisa 1 is sufficient for the time being and there is no need to rewind them. The Loviisa 1 pumps are smaller than those of Loviisa 2 are.

Re-coating of Loviisa 1 steam generator room floor

During the 2000 annual maintenance a water leak had occurred at the plant unit in consequence of which the floor coating came off in several places (STUK-B-YTO 208, 2001). The floor was temporarily repaired by removing loose coating sections and by applying a new layer of coating on the bare concrete floor. Final coating work was scheduled for forthcoming annual maintenance. During the 2001 annual maintenance outage, about one fifth of the floor area was coated. Old coating was removed insofar as it was not firmly "bound" to the base. Work proceeded as planned and the worker radiation doses were noticeably lower than assessed prior to the work.

The coating work will continue in forthcoming annual maintenances and the floor re-coating job is due for completion in 2005. In a possible leak situation, the coating prevents water and any radioactive substances in it from being absorbed into the floor concrete. The radioactive substances in the concrete could add to the radiation exposure of workers even after the leak situation. Owing to the coating, which is even decontaminable, leak waters end up in the radioactive water treatment system.

Olkiluoto power plant

Plant modifications providing against accidents

In the annual maintenance outages of both Olkiluoto plant units modifications were made to provide against severe accidents. The most time-consuming of them was the strengthening of an Olkiluoto 1 containment building personnel lock. The modified containment withstands considerably heavier individual pressure shocks than before. Such shocks could occur in a severe accident during which the reactor core would melt and the molten core would penetrate the reactor pressure vessel and enter the water pool in the containment drywell. Under certain circumstances, when molten fuel comes into contact with water, a "steam explosion" could be generated. At Olkiluoto 2 the modification is due in 2002.

Another significant modification was the installation of a new lye tank at the water supply system. Lye can be channelled from the tank to the containment to regulate the pH of water in the containment in such a way that any iodine accidentally released would be contained as efficiently as possible. The tank is shared by the two plant units.

The need to install the lye tank to improve iodine retention was demonstrated in a study commissioned to the Technical Research Centre of Finland (VTT) by STUK. The study examined the behaviour of iodine in accident situations at Olkiluoto facility. It experimentally demonstrated that unless the pH of the containment building water pools is regulated, i.a. by lye addition, acidification of the water could result. A significant part of the iodine released within the containment would then gasify and could form organic compounds that would not be efficiently retained in the filter of the containment filtered relief system. The plant modification designed by the licencee aims at preventing the creation of such unfavourable circumstances.

Renewal of the reactor control rod manoeuvring and position indication system of Olkiluoto 2

Olkiluoto 2 systems for the control and position indication of reactor control rods were renewed during annual maintenance. The most part of the position indication system was replaced. Included in the system were selection functions for the control rods to be manoeuvred and the collection of manoeuvring data. Control rod control was thus made more accurate and rod position data reporting and tests were enhanced

The control rod manoeuvring and position indication system collects and transmits data on rod positions in the reactor to the operator and the plant unit's process computer system. The new system's data processors generate also signals indicating the rods to be manoeuvred for transmission to the control rod manoeuvring system. The selection signals used to be generated by process computer.

The system generates manoeuvring signals for the reactor's 121 control rods by combining selection signals coming from the position control system with manoeuvring signals initiated by the operator. In addition, the system transmits protection signals generated by safety systems or initiated by the operator to shut down the reactor or to limit reactor power.

The power supply components of control rod drive motors at the switchgear plant were replaced. The contactor switching on the control rod withdrawal function was doubled in series, which reduced the probability of erroneous withdrawal due to contactor failure. System monitoring for unnecessary rod withdrawals caused by internal faults in the control rod manoeuvring system was improved at the same time.

The rod local manoeuvring system in the instrumentation rooms near the control room was extended to comprise four control posts, whereas the old system had two. The selection of locally manoeuvred control rods was renewed as well and is now carried out on a programmable user interface belonging to the rod position indication system.

The renewal of the rod manoeuvring and position indication system at Olkiluoto 1 is due for implementation in the 2002 annual maintenance.

During the functional testing and commissioning of the renewed systems some unnecessary failure signals and erroneous measurement data was observed by the licencee. In addition, control rod selection failed in some special situations. The failures were mainly attributed to the electrical connections of different system parts, which were not compatible in all situations. The failures having the most bearing on operation have been fixed by software modifications and a repair schedule for the rest has been set by the utility.

Renewal of the measurement computer systems of the Olkiluoto plant units

The Olkiluoto 2 measurement computer system was renewed in the 2001 annual maintenance outage. It comprises equipment facilitating the work of the operating and maintenance personnel in monitoring and clarifying the course of transients at the plant units as well as making possible the analysis of gathered data.

The old system has been on normal standby and, on specific alarm signals, has started the collection of data on important plant unit parameters during transients. It has also recorded plant unit operation in special situations, such as important tests. The plant unit has renewed the system's data gathering and processing equipment to improve availability and maintainability. A corresponding modification was made at Olkiluoto 1 in the 2000 annual maintenance.

The new system collects measurement data by programmable processors and it has considerably more inputs than had the old system. In the new system 416 analogue and 128 binary inputs can be used. Data is transferred from processors to individual workstations. They continuously gather data so that their memory always contains one week's event history. Applicable analysis software is available on the workstations for examination of the measurement data.

Rotating converters replaced by UPS equipment

A modification project was launched at the Olkiluoto plant units during the 2001 annual maintenance during which ageing direct/alternating current converters are replaced by modern UPS equipment. A rotating converter unit comprises a direct-current motor rotating an alternating-current generator. The converter unit assures electrical power supply to the battery-backed 400 volt alternating current system under all operational conditions of the plant units. Both Olkiluoto plant units have four converters.

The converters were renewed owing to their increasing maintenance costs, inferior efficiency and ageing-related malfunctions.

One new piece of UPS equipment was installed and commissioned at Olkiluoto 1 and two at Olkiluoto 2 during the 2001 annual maintenance outages. The remaining five pieces of equipment are due for installation in 2002.

Cathodic protection of service water channels

An impressed current cathodic protection system was installed at some points of the service water tunnels at both Olkiluoto plant units for corrosion control of reinforcement steels. This electro-chemical corrosion prevention method utilises an electric current to make metal surfaces immune to corrosion. At the Olkiluoto plant units electric current is fed from a direct-current supply to reinforcement steels via insoluble auxiliary anodes. In addition, the system includes reference electrodes controlling the operation of the direct-current source.

The problem with concrete service water tunnels is that the salt in sea water migrates into the concrete causing corrosion of the reinforcement steels inside it. The service water of the Olkiluoto plant units is channelled to turbine condensers and to the service water tunnels of the auxiliary building and back along tunnels partly built in rock, partly in concrete.

The licencee plans to later extend cathodic protection to cover all service water channels made of concrete.

Modernisation of the fire detection system

The automatic fire detection system of the Olkiluoto power plant has been replaced. The old equipment had aged and did not meet modern requirements on system operation and reliability. Spare parts procurement had also become difficult.

The old system's cabling was used to the extent possible in constructing the new system. The old system's fire detection circuits were installed in the new system one one by one. The basic technology of the new system is similar to that of Loviisa power plant's fire detection system whose reconstruction is described earlier in this Appendix.